

# Water Quality Research Program Multi-Year Plan

Office of Research and Development

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The Office of Research and Development's (ORD) multi-year plans (MYPs) present ORD's proposed research (assuming constant funding) in a variety of areas over the next 5-8 years. The MYPs serve three principal purposes: to describe where our research programs are going, to present the significant outputs of the research, and to communicate our research plans within ORD and with others. Multi-year planning permits ORD to consider the strategic directions of the Agency and how research can evolve to best contribute to the Agency's mission of protecting human health and the environment.

MYPs are considered to be "living documents." ORD intends to update the MYPs on a regular basis to reflect the current state of the science, resource availability, and Agency priorities. ORD will update or modify future performance information contained within this planning document as needed. These documents will also be submitted for external peer review.

## **PREFACE**

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## Table of Contents

Introduction .....	1
Scope of the Plan .....	7
Long Term Goals and Science Questions .....	8
Setting Priorities and Science Questions .....	8
Annual Performance Goals and Measures: The General Roadmap and Challenges ...	11
Long Term Goal 1 .....	14
Summary of Research Questions and Approaches .....	14
Expected Impact and Outcomes .....	15
Long Term Goal 2 .....	15
Summary of Research Questions and Approaches .....	15
Expected Impact and Outcomes .....	17
Long Term Goal 3 .....	17
Summary of Research Questions and Approaches .....	17
Expected Impact and Outcomes .....	18
Long Term Goal 4 .....	19
Summary of Research Questions and Approaches .....	19
Expected Impact and Outcomes .....	19
Resource Allocation Among the Long Term Goals .....	20
Summary of the Non-EPA research supportive of the LTGs .....	20
Concluding Notations for Current Resource Base .....	22
Unfunded Priorities .....	22
Appendix .....	51

## List of Tables

Table 1. Long Term Goals and Priority Science Questions .....	13
Table 2. Relative Resource Trends Among the Long Term Goals .....	20
Table 3. Long Term Goal 1 .....	25
Table 4. Long Term Goal 2 .....	34
Table 5. Long Term Goal 3 .....	38
Table 6. Long Term Goal 4 .....	44

## List of Figures

Figure 1. Goal 2 Context for Water Quality Multi-year Plan .....	3
Figure 2. Water Quality Framework .....	4
Figure 3. Relationship of OW Programs and Science Needs to ORD Research Areas ....	9
Figure 4. Setting Priorities for the Water Quality Multi-year Plan .....	10
Figure 5. Long Term Goal 1 .....	46
Figure 6. Long Term Goal 2 .....	47
Figure 7. Long Term Goal 3 .....	48
Figure 8. Long Term Goal 4 .....	49

## Introduction

The Water Quality Multi-year Plan (MYP) is one of 16 MYPs developed by the Office of Research and Development. The purpose of the MYPs is to aid ORD as a planning and communication tool. Multi-year planning allows ORD to consider the future strategic direction of the Agency, as described in the EPA and ORD Strategic Plans, and determine where scientific discovery can contribute. MYPs also help ensure the relevance, quality, and performance of our research program.

The primary client for the Water Quality MYP is the U.S. EPA's Office of Water. The research to support the Office of Water's Goals under the Clean Water Act (CWA) is described, or referenced, in this document. The Long Term Goals (LTGs) guiding research for the next 5-8 years are given in the text box below. By design, the long term research goals and the interim steps and planned accomplishments proposed here are directed specifically to enhance the science and engineering content of EPA, State, and local action programs. Accordingly, ORD envisions this research as the "application and demonstration vehicle" for both its relevant science programs described in Goal 4 (Healthy Communities and Ecosystems) and the fundamental and applied science needed to underpin the strategic goals for the Agency Goal 2 (Clean and Safe Water) programs. Consistent with this approach, many of the annual goals and planned products are phrased as "providing tools and data for..." or as "demonstrating the application to achieve..." where the specific goals or products correspond to one or more of the major logical steps required to meet the Nation's water quality goals.

### TEXT BOX 1

#### **Water Quality Long Term Research Goals**

**LTG 1: Provide the approaches and methods to develop and apply criteria for habitat alteration, nutrients, suspended and bedded sediments, pathogens and toxic chemicals that will support designated uses for aquatic systems**

**LTG 2: Provide the tools to assess and diagnose the causes and pollutant sources of impairment in aquatic systems**

**LTG 3: Provide the tools to restore and protect impaired aquatic systems and to forecast the ecological, economic, and human health benefits of alternative approaches to attain water quality standards**

**LTG 4: Provide the approaches, methods and tools to assess the exposures and reduce the human health risks from biosolids contaminants for use by OW, States and others in updating biosolids guidance and regulations**

The level of resources for Water Quality research in Fiscal Year (FY) 2003 is approximately \$45 Million including 225 full time equivalent (FTE) personnel.

## **Background**

The conceptual and logical description of the EPA's Water Quality programs are provided in Figures 1 and 2. Included in Figure 1 are the relevant Agency policy instruments on the left-most column; included as the right-most columns are the typical research topics from both this plan and relevant topics from ORD's core research program in Goal 4. Figure 2 illustrates the same support and cross-connection keyed to a recent description of the Agency's watershed approach as provided by the Office of Water. In addition to the Agency's mandates to guide and enhance our meeting "fishable and swimmable" clean water goals, a number of specific and technology-based components of the Act require periodic or stake-holder driven increased attention. This plan also includes the specific issue of generation, treatment, and use/disposal of biosolids. Biosolids are sewage sludge that have been treated in accordance with 40 CFR Part 503 (the "Part 503 rule"). Land application is one of several management options for biosolids and disposal of biosolids. In this case, the EPA commissioned a review of current practices and regulations for land application of biosolids by the National Research Council (NRC) which has recommended research issues that should be addressed. Accordingly this Plan includes ORD's response to that study. The Long Term Goals for this Multi-Year Plan included in Text Box 1 reflect both the logical construct of the Agency's programs and the current priority among a much broader programmatic effort.

The programmatic processes outlined in Figures 1 and 2 are not entirely new. The details of each of the programmatic and policy-level programs will not be repeated here; such information is available from the Agency's Office of Water's Strategic Plan and other web-site materials available from the OW (<http://www.epa.gov/ow>). While the programs are varied and seemingly complex, the major drivers for this research plan are the Agency's watershed approach, specific regulatory and guidance "tracks", and the Total Maximum Daily Load (TMDL) program. A TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources. Analysis and implementation are via watershed management, water quality restoration and protection.

ORD has been engaged in supporting the science needs of various aspects of the relevant portions of the CWA for a number of years. Particularly, ORD has developed and defended chemical water quality criteria, conducted dose-response experiments and developed cause-effect models, provided hydrologically-based modeling frameworks and models for TMDL modeling, investigated the performance and costs of treatment technologies, developed and evaluated best management practices, and provided indicators for assessing biological condition. A number of environmental and institutional trends have emerged from application and use of previously developed science and technology.

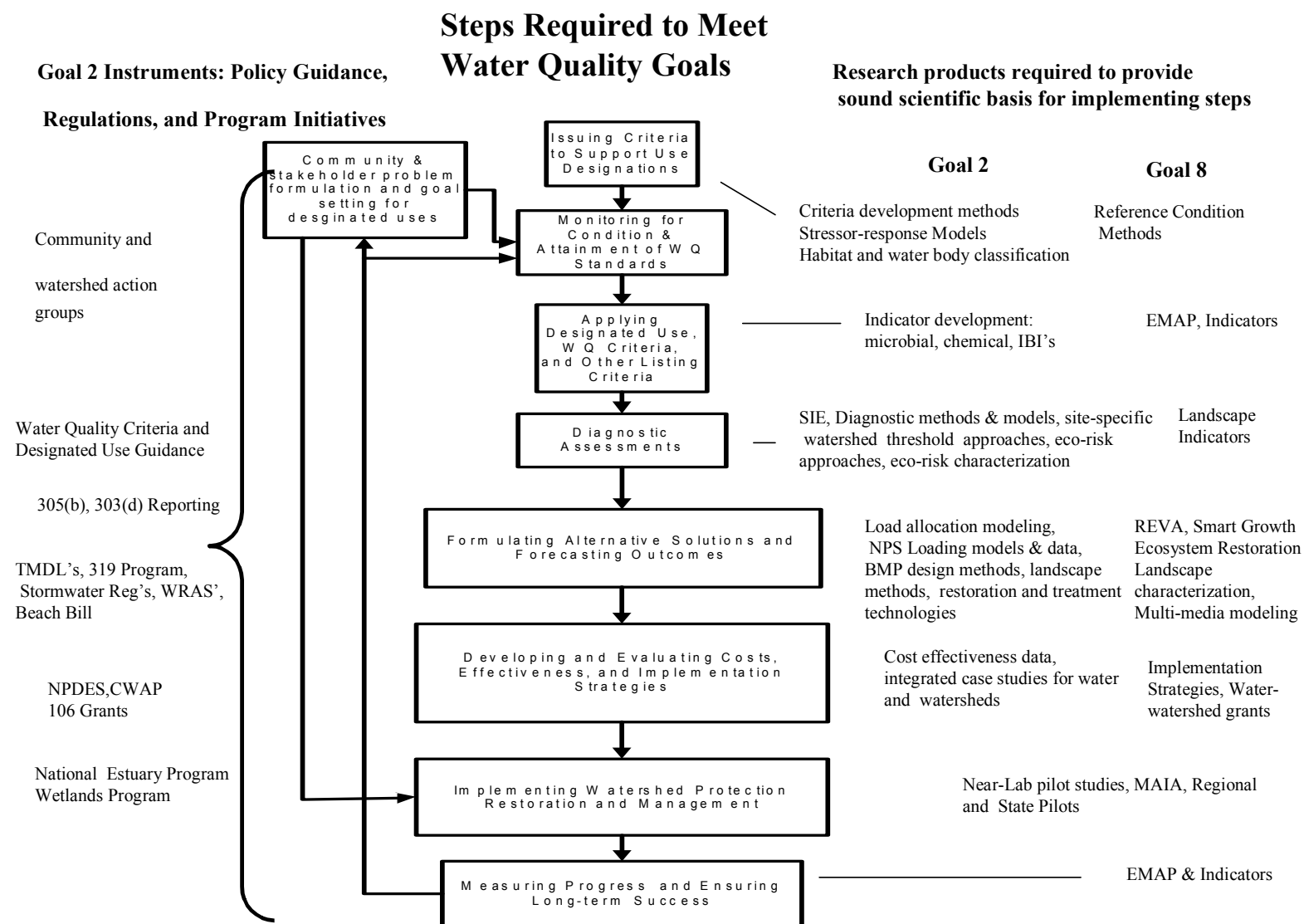


Figure 1. Goal 2 Context for Water Quality Multi-Year Plan

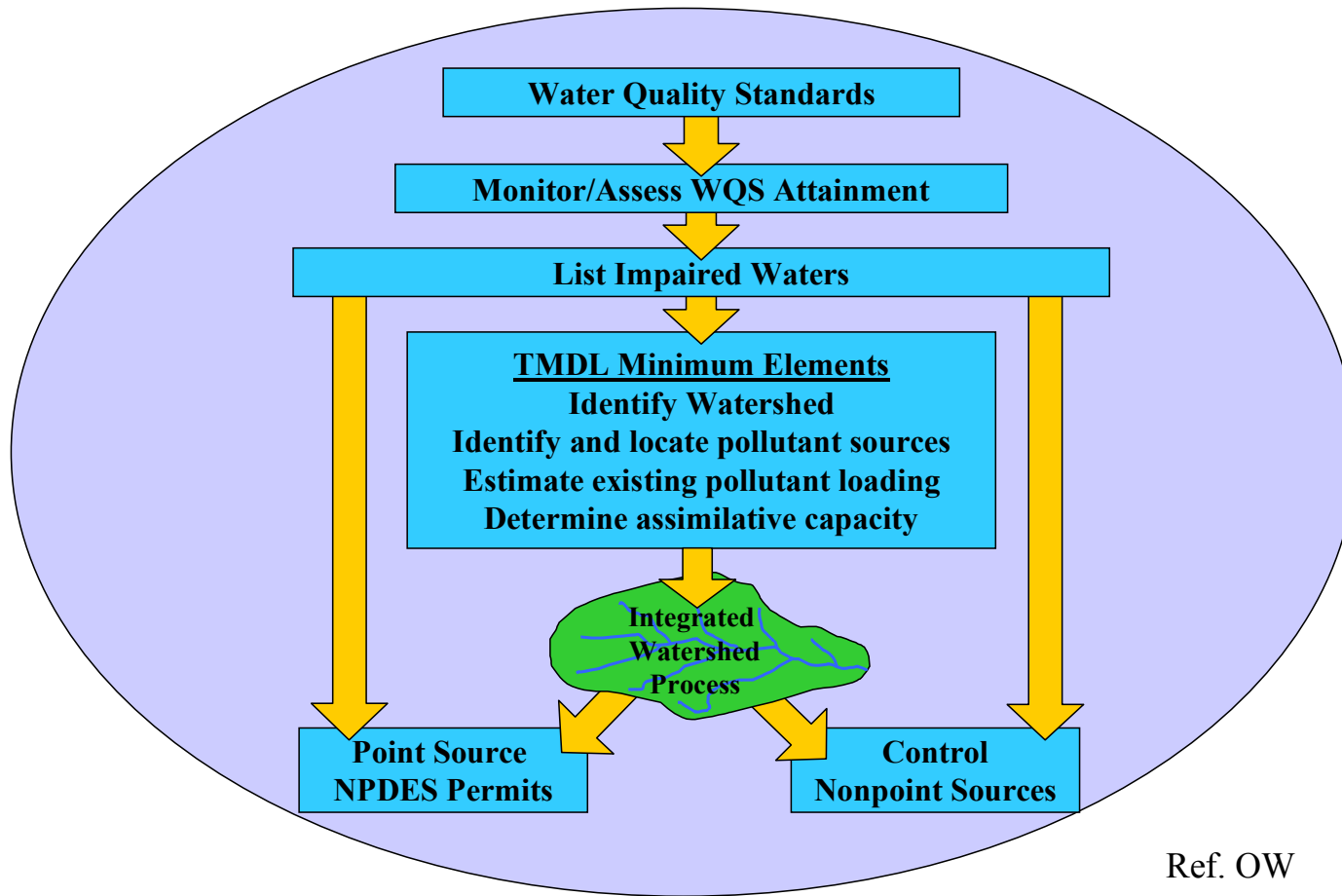


Figure 2. The “Problem,” a.k.a. Water Quality Framework

Among the major trends that present remaining challenges are:

- ▶ over 20,000 waters identified by States as impaired due to one or more pollutants
- ▶ a shift from point source discharges as the major source of pollutants to nonpoint sources
- ▶ an increasing use of biological indicators and metrics as the preferred method for determining the condition of aquatic ecosystems
- ▶ an increasing awareness of the importance of landscape- and watershed- scale processes and activities as determinants of water quality
- ▶ an increasing awareness of the role of atmospheric deposition and multimedia sources as determinants of water quality
- ▶ an increasing awareness of the role of habitat alteration as a cause of aquatic ecosystem impairment
- ▶ an increase in human-health risks from apparent ecosystem responses to stressors, particularly pathogens
- ▶ pressures to increase the efficiency and cost-effectiveness of implementation
- ▶ an increase in the role of citizen stakeholders in setting watershed management goals and in implementing action programs at the local and watershed levels
- ▶ increasing calls for more efficient, more nearly accurate models and methods, and more explicit representation of uncertainties in decision-making processes used by EPA and State Agencies (NRC, 2001)
- ▶ lack of systematic and statistically-robust evidence that best management practices (BMP's) for non-point source controls are working
- ▶ increasing calls for outcome-based implementation and accountability
- ▶ increasing calls for documentation of the economic benefits derived from Agency approaches to meet Water Quality Standards and Goals
- ▶ an increasing awareness of the role of invasive species as a cause of aquatic ecosystem impairment
- ▶ integrated assessments for allocation of restoration resources to support water quality standards attainment within the context of socioeconomic factors

- ▶ recycling of biosolids through field application is the preferred method for biosolids management, but there is increasing public concern that biosolids land application practices may be causing adverse health effects in nearby residents
- ▶ the NRC and others have called for an update of the scientific basis for the Part 503 rule, particularly for Class B biosolids - those that are treated to reduce pathogens but still contain detectable levels of them and consequently are restricted in their use.

The trends and challenges cited above drive the current research agenda and help set the priorities laid out in this multi-year plan. In particular, previously developed and current science and technologies are apparently inadequate to meet the challenges for the following reasons:

- ▶ BMP's and other nonpoint source control measures have rarely been evaluated for their effectiveness in achieving improved water quality (particularly biological condition), rather only for pollutant load or concentration reduction
- ▶ previous focus on chemical and pollutant-specific determinants of water quality does not fully address biological condition
- ▶ the data, analysis tools, and assessment methodologies for landscape and regional scale processes are leading edge research areas not yet exploited to solve problems
- ▶ atmospheric deposition of nutrients (e.g., nitrogen) and toxic substances (e.g., mercury) have not been integrated into watershed management science
- ▶ biological indicators and measurements of habitat alterations, particularly related to flow and sediment, have only recently emerged as issues
- ▶ the causes and control of increasing hazardous algal blooms (HAB's), *Pfiesteria*, and pathogens are not fully known
- ▶ ecological risk assessment guidelines, public awareness tools, and risk communication programs are largely new and rarely applied
- ▶ free market based and economically robust risk management systems and frameworks are limited in scope and application
- ▶ many models and decision-support tools are often cumbersome to apply, require data all too often unavailable, and fail to explicitly address uncertainty
- ▶ guidance for setting action and management priorities to achieve outcome-based goals remains problematic

- ▶ water quality management solutions that also lead to sustainable ecosystems and related economies are desirable; the ability to design and implement such solutions is lacking, in large part because of scientific limitations.
- ▶ economic valuation of water quality benefits cannot yet be applied to action programs and regulatory activities
- ▶ assessing exposures and risks of critical pathways and contaminants are limited by the lack of improved scientific information and tools to identify hazards of biosolids application.
- ▶ there are limited tools for analyzing pathogens and emerging chemicals in biosolids
- ▶ there are limited data on the appropriate use of existing or emerging biosolids management techniques to minimize human health risks.

## **Scope of the Plan**

Note that the long-term goals in Text Box 1 follow the logical construct of the steps in Figures 1 and 2. Simply stated, ORD envisions a logical progression in meeting water quality goals by: 1) setting water quality criteria that are logically connected to specific designated uses; 2) monitoring for the condition of designated water bodies and listing those having impairment; 3) applying relevant criteria and stakeholder input to evaluate if action programs are needed to either protect high quality systems or to restore impaired waters; 4) diagnosing the causes of observed impairment (stressors) and determining the sources of the stressors; 5) developing an array of technologies, management, and restoration actions that can be deployed to protect high quality habitats, restore degraded systems to desired designated uses, and protect public health; and 6) deploying institutional, implementation, and monitoring systems to ensure that long-term and sustainable success is achieved. The geographical scope of the problem is national and both freshwater and coastal systems are included. Critical habitats, particularly wetlands and riparian zones, are included, largely as a part of the surface water network subject to the processes in Figures 1 and 2. While other specific and perhaps critical or unique habitats and features of the landscape are of interest to the Office of Water, ORD has made a strategic decision to limit the scope of our research so that we can focus on high priority issues presented by TMDL's and related processes identified in Figure 1. In a later section of this Plan, ORD will identify areas of needed emphasis should additional resources become available.

The plan described in this document includes pathogens as a priority stressor. Pathogens are regulated via both the Clean Water Act (CWA) and the Safe Drinking Water Act (SDWA). Only the CWA is considered here, with logical references to the Safe Drinking Water Act. Accordingly, the scope of this plan for pathogens includes: TMDL-driven issues (i.e., setting and meeting limits on loadings of pathogens from point and nonpoint sources); the role of aquatic ecosystems in the survival and proliferation of human and ecological pathogens; ecosystem-

derived harmful microorganisms (e.g., hazardous algal blooms (HAB's)); and development of human exposure and effects data for risks in recreational water use designations.

ORD will support the specific steps illustrated in Figure 1 by providing data, methods, models, and experimental protocols. ORD will also investigate innovative approaches that could transform currently configured complex processes (e.g., TMDL's) into profoundly simpler and more cost-effective ways to meet water quality goals. Accordingly, ORD envisions interactive partnerships with both the Office of Water and the State, interstate, and local agencies charged under the Clean Water Act to design and implement action programs.

## **Long Term Goals and Science Questions**

### Setting Priorities and Formulating Science Questions

Resource materials that inform the content and priorities of this plan are derived in the most part from the body of information jointly developed by ORD and the Office of Water through the Strategic Planning and Research Coordination (SPRC) workshops held during 1999 - 2002. The purpose of these workshops was to establish joint goals and strategic research directions in OW program areas related to water quality and aquatic ecology. Figure 3 was used as a coordinative guide to relate the OW program and science needs to the ongoing ORD research areas. While this figure is somewhat dated, having been developed in 1999, it is instructive to modify the figure by adding the right-most column as a means to inter-relate current ORD Multi-Year Plans. This figure shows that research planned and budgeted in Goals 4 (Healthy People, Communities and Ecosystem - Ecological Research), 5 (Compliance and Environmental Stewardship - Pollution Prevention Research), and in Goal 3 (Land) also support the Long Term Goals identified in this Plan.

Observations from the Regions and States on the condition of U.S. waters were heavily weighted in the SPRC workshops and in development of this plan. ORD attended a National meeting of the EPA Regional coordinators for nonpoint sources, monitoring, and TMDL's and used a questionnaire to query the group on the contents of this MYP. The response was remarkably positive and supportive with notable requests for more integrated products and technical support for monitoring and modeling.

The SPRC workshops resulted in the development of comprehensive "research needs" and "program needs" statements. ORD subsequently followed up with detailed in-house planning activities. Notable among these efforts is NHEERL's science planning for aquatic stressors (Aquatic Stressors: A Framework and Implementation Plan for Effects Research 2002, EPA 600/R-02-074). Another notable effort was the generation and publication of five white papers on the risk management of sediments, nutrients, toxics, flow, and pathogens by NRMRL.

Science planning documented in MYP's must be sufficient to enable and guide the detailed project planning steps at the Division and Investigator levels. This MYP is intended to provide

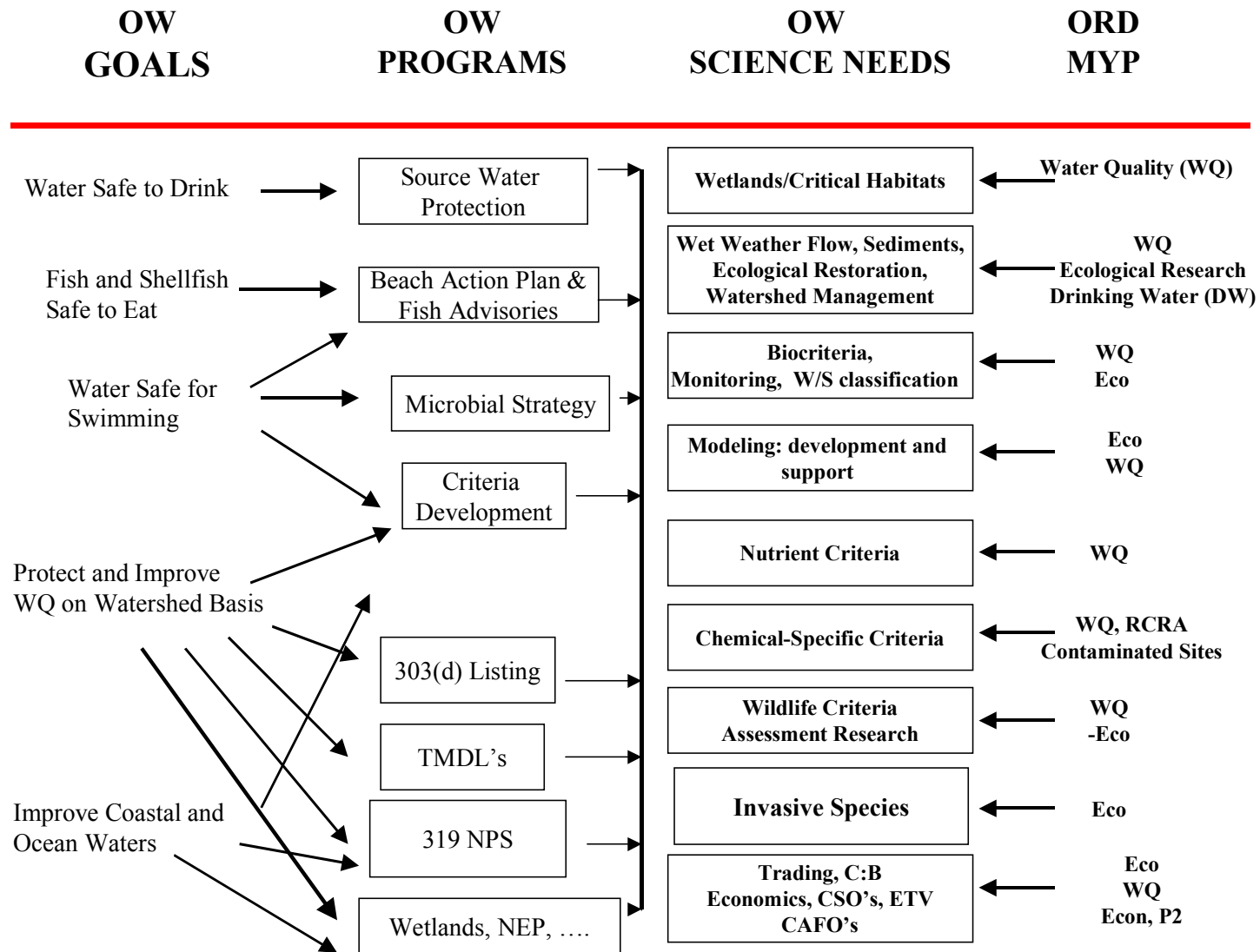


Figure 3. Relationship of Office of Water Program and Science Needs to ORD Research Areas

the “top down” priorities and expectations for detailed water quality science planning at the bench and field level within and among the ORD Laboratories and Centers. While the science questions included in this plan are projected to be appropriate and the related outputs and goals the “right” milestones, the reader should understand that detailed implementation planning is not the intent nor the content.

Priorities within this plan were selected by “weighing” the combination of the reported reasons for listing U.S. waters as impaired and the levels of uncertainty the Agency and States face in using the steps in Figures 1 and 2 to achieve water quality goals, i.e. restoring the impaired waters and maintaining designated uses. Conceptually the priority-setting approach is illustrated in Figure 4. An elaboration on priorities is useful here because the priorities identified in this plan imply changes in the content and pace of ORD’s research. It is also true that ORD envisions this as an ongoing process that will require reconsideration of the current plan on a biennial basis.

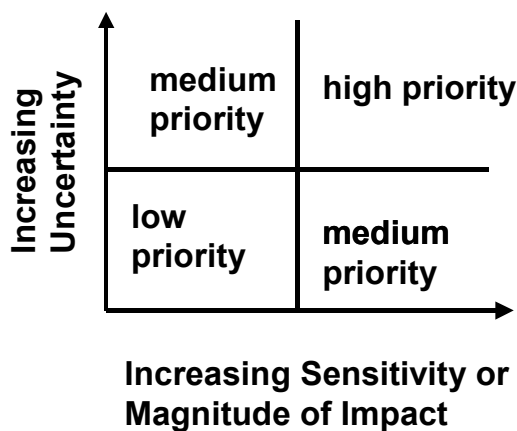


Figure 4. Setting Priorities for the Water Quality Multi-Year Plan

Consider, for example, nutrients, pathogens and suspended and bedded sediments, which are the most-cited stressors reported by the States as the reasons for listing U.S. waters as impaired. Recall that such listings set in motion many of the policy and regulatory steps depicted in Figures 1 and 2, including requirements for setting and implementing TMDL’s. Accordingly, nutrients, pathogens and suspended and bedded sediments would occupy a “high” position on the x-axis of Figure 4. That is, the listing process is demonstrably “sensitive” to these stressors and their impact on water quality is judged to be substantial. From an uncertainty perspective, (the

y-axis of Figure 4) the ability to reliably measure pathogens and to infer their sources within watersheds is very limited and the quantitative dose-response data for suspended and bedded sediments are virtually non-existent. Clearly, in these cases, uncertainty is also “high”. This uncertainty is a major, if not an absolute, limiting factor in the ability of the Agency and States to successfully implement the steps (Figures 1 and 2) needed to meet water quality goals. And, a high priority “weight” is now attached to these problems. This process is, of course, somewhat qualitative but it is also believed to be reasonably objective. (Actually, it is also akin to the concepts of “analysis of the value of data” and first-order error analyses, both representing formal analytical and mathematical procedures.)

Another perspective on the use of Figure 4 is application to the four LTGs. (See Text Box 1.) While meeting all the goals is critical to Agency programs and success, the recent NRC study calls for increased attention to the “listing problem” and for more explicit “adaptive management” approaches for implementing TMDL requirements. Accordingly, this MYP has proposed relative increases in resources for LTGs 2 and 3, within an overall level-resource environment.

Table 1 provides specific research questions and topics under each LTG. Approximate time frame for their completion is in the figures and tables to follow. The content as expressed in annual performance goals and measures and their respective timing reflect the priorities as judged by the above process.

Note that the questions in Table 1 are informed by additional specific information. For example, the order and specificity of the major stressors (suspended and bedded sediments, pathogens, nutrients, etc.) reflect the outcomes and priorities of the ORD-OW workshops. This does not mean that all ORD resources will be deployed in a simple sequential fashion in order to answer the questions, rather that the detailed science planning at the Division and investigator levels should reflect the topics in a balanced and sufficiently focused manner so that the questions can be answered in a timely fashion. The importance of this principle cannot be overstated – projected resource levels simply do not accommodate **relevant** but **lower priority** research.

#### Annual Performance Goals and Measures: The General Roadmap and Challenge for Meeting Agency Long Term Goals

Meeting the Agency long term goals and their related research goals by answering the associated research questions summarized in Table 1, will enable OW, the Regions, the States, and watershed stakeholders to develop and apply creative and robust approaches to meet Clean Water Act requirements. The steps illustrated in Figure 1, while straight-forward in form, operate in a challenging institutional environment of multiple interests, diverse constituencies, overlapping jurisdictional boundaries, and calls for accelerated time frames. Such operational complexities produce pressures for “faster, cheaper, more accurate” solutions. The overriding public interest is in the outcome – clean water on a sustained and sustainable basis.

The annual performance goals and measures outlined in this plan are designed to provide a product stream of data, methods, models, and tools that both recognize the operational complexities of Figure 1 and that support the specific steps taken by the various entities charged with clean water action programs (of course, all entities respond to the Agency's policy development and guidance). All stakeholders serve the interest to protect high quality aquatic systems and to restore U.S. waters currently listed as impaired.

Stakeholders and resource managers need to be able to set criteria or goals and monitor for condition, to identify and list impaired waters for action, to diagnose the causes and sources of current and future problems, and to formulate and implement cost-effective prevention and restoration solutions. Some stakeholders need support in making local decisions and implementing action programs while others need support in formulating policies that integrate multi-objective interests while providing improved water quality outcomes.

Operational time-lines among States and other stakeholders are variable with some depending on rotation cycles among river basins or watersheds within a given jurisdiction, while others are following a litigation-based schedule mandated by the Courts. The problem remains to provide the science necessary to inform decision-making and document outcomes across this range of needs. A specific time-frame from FY03 through FY08 has been adopted for this plan. The cyclical and ongoing nature of the Clean Water Act will require both operational and research support beyond the FY08 target.

**Table 1. Long Term Goals and Priority Science Questions**

**Long Term Goal 1: Provide the approaches and methods to develop and apply criteria for habitat alteration, nutrients, suspended and bedded sediments, pathogens and toxic chemicals that will support designated uses for aquatic systems**

- What are the quantitative and causal relationships between varying levels of stressors, alone and in combination, and the biological response of aquatic ecosystems and the resulting services such systems provide? For habitat alteration? For nutrients? For suspended and bedded sediments? For pathogens? For toxic chemicals?
- What are the best ways to classify ecosystems, landscapes, and watersheds to enable efficient and scientifically sound development and application of indicators, biocriteria, listing criteria, and water quality criteria?
- How can stressor levels, biological-response relationships, classification schemes, bioassessment methods, ecological risk assessments, and indicators be applied across U.S. surface waters to set criteria for identifying/restoring impaired waters and maintaining designated uses?

**Long Term Goal 2: Provide the tools to assess and diagnose the causes and pollutant sources of impairment in aquatic systems**

- How can multiple and possibly related causes of biological impairment be inferred from indicator and other observations, and cause-effect modeling? For habitat alteration? For nutrients? For suspended and bedded sediments? For pathogens? For toxic chemicals?
- How can the sources and source strengths of stressors be inferred from *in situ* measurements? From stressor measurements? From biological indicators? From remotely-sensed observations and watershed properties?
- How does one determine the most appropriate and efficient scale for application of diagnostic methods within the TMDL and 303(d) process?

**Long Term Goal 3: Provide the tools to restore and protect impaired aquatic systems and to forecast the ecological, economic, and human health benefits of alternative approaches to attain water quality standards**

- What additions to models are most needed for the TMDL process? For habitat alteration? For nutrients? For suspended and bedded sediments? For pathogens? For toxic chemicals?
- What BMP's treatment systems and restoration technologies remain as uncertain options for watershed management? For mixed land use watersheds? For habitat alteration? For nutrients? For suspended and bedded sediments? For pathogens? For toxic chemicals?
- How can classification schemes, modeling scenario analyses, landscape classification, and economic projections be applied to provide alternatives for meeting water quality goals efficiently at multiple scales? What are the economic benefits of watershed management?

**Long Term Goal 4: Provide the approaches, methods and tools to assess the exposures and reduce the human health risks from biosolids contaminants for use by OW, States and others in updating biosolids guidance and regulations**

- Do contaminants in biosolids pose a significant health risk to the public when applied in compliance with current regulations?
- What additional models, tools and methods are needed to identify, measure and assess aggregate exposure pathways and risks?
- What improved analytical techniques can be developed to adequately determine pathogen and priority toxic chemicals in or released from biosolids?
- What is the current state of management practices for biosolids production and application, and how can those be made more effective?

Consider in detail the first Long Term Goal.

**Long Term Goal 1. Provide the approaches and methods to develop and apply criteria for habitat alteration, nutrients, suspended and bedded sediments, pathogens and toxic chemicals that will support designated uses for aquatic systems**

**Summary of Research Questions and Approaches**

- What are the quantitative and casual relationships between varying levels of stressors, alone and in combination, and the biological response of aquatic ecosystems and the resulting services such systems provide? For habitat alteration? For nutrients? For suspended and bedded sediments? For pathogens? For toxic chemicals?
- What are the best ways to classify ecosystems, landscapes, and watersheds to enable efficient and scientifically sound development and application of indicators, biocriteria, monitoring and assessment methodologies, and water quality criteria?
- How can stressor levels, biological-response relationships, classification schemes, bioassessment methods, ecological risk assessments and indicators be applied across U.S. surface waters to set criteria for identifying /restoring impaired waters and maintaining designated uses?

ORD envisions an approach to meeting the first Long Term Goal that develops and integrates indicators, classification schemes, stressor-response relationships and modeling, and bioassessment methods into generally applicable ways to set criteria for a wide array of designated uses. ORD's role does not currently extend to deriving criteria, rather to provide the science to develop improved or new criteria. The recent National Research Council (NRC) study on TMDL's has recommended that more comprehensive and flexible consideration be given to listing impaired waters. While this recommendation may be directed to policy constructs within TMDL and Agency monitoring guidance, the related scientific issue includes the rationale for relating designated use to water quality criteria.

Table 2 arrays the APG's and APM's proposed to meet this goal. Figure 5 shows the linkage and timing of the proposed Annual Performance Goals for this Long Term goal. Note that the structure of the APG's illustrated in Figure 5 implies both the provision of relevant and necessary science and the application, or, demonstration, of the science. The structure and choice of wording were deliberate; ORD needs to both produce peer-reviewed science and to demonstrate via application and case studies that the research can be used to satisfy the requirements shown in Figure 1.

Priorities include increased stressor-specific efforts for sediments, nutrients, pathogens, and highly persistent bioaccumulative toxic chemicals (PBT's) for the protection of wildlife populations. Bioassessment research is proposed to continue as a field-oriented approach to

setting biocriteria as the basis for relating designated uses to biological condition in streams and rivers.

Research for this long term goal builds on a longstanding program having already “plucked the low-hanging fruit.” Much of the remaining work will focus on aquatic populations and communities and will specifically address multiple stressors. In the case of nutrients, a strategic decision has been made to focus on coastal and Great Lakes systems with an expectation that the knowledge gained will address national priorities (hypoxia in coastal systems) that can be extrapolated across a wide array of geographical systems (e.g., streams, rivers, lakes and wetlands). In the case of suspended and bedded sediments, this MYP sets near term goals but defers projection of expected research products pending a state of the science assessment on the topic and the integration of these results with research being conducted under the Goal 4 Ecological Research MYP.

Research progression over time is envisioned as moving from laboratory and conceptual approaches of increasing complexity to watershed and regional demonstrations as part of interactive partnerships with Regions and States. The Logic Flow Diagram of Figure 5 illustrates the cumulative progress over time for the major stressor categories (habitat alteration, nutrients, suspended and bedded sediments, pathogens, and toxic chemicals).

### **Expected Impact and Outcomes**

Currently, the States operate from a mixture of narrative and numerical water quality criteria. The major causes of impairment (nutrients, pathogens, and suspended and bedded sediments) often reflect nonattainment of narrative criteria caused in many cases by episodic events and that will require, over time, numerically-based reductions in loads and monitoring of the outcomes. If successful, the research outlined for this goal will enable the Agency and States to avoid over-or under- managing stressors and their related costs. National, regional, and watershed-based management strategies for stressors discussed in the plan (e.g. nutrients, pathogens, etc.) that are based on criteria thresholds and quantitative targets will emerge. While ORD has not set targets for the number and extent of States and other organizations that develop water quality criteria or standards based on products in Table 2, such statistics will best document the outcomes of this research.

Now, consider Long Term Goal 2 in more detail.

### **Long Term Goal 2. Provide the tools to assess and diagnose the causes and pollutant sources of impairment in aquatic systems**

#### **Summary of Research Questions and Approaches**

- How can multiple and possibly related causes of biological impairment be inferred from indicator and other observations, and cause-effect modeling ? For habitat alteration?

For nutrients? For suspended and bedded sediments? For pathogens? For toxic chemicals?

- How can the sources and source strengths of stressors be inferred from *in situ* measurements? From stressor measurements? From biological indicators? From remotely-sensed observations and watershed properties?
- How does one determine the most appropriate and efficient scale for application of diagnostic methods within the TMDL and 303(d) process?

Once an impaired water body is listed for restoration, it is rarely the case that the exact causes of the impairment and the stressor sources are known. Indeed, the NRC report (June 2001) suggests that the process of listing impaired waters in the first place (the CWA as amended, 303(d) listing process) may have identified waters that should be further analyzed before TMDL and restoration actions are required. While such recommendations are policy-related, an important science issue is clearly raised: what is the most robust and practical approach for identifying impaired waters for further analysis and actions? Accordingly, ORD has developed a diagnostic research program having two dimensions. First, ORD is developing approaches and diagnostic methods that encompass the analysis of watershed, land use, hydrological properties, biological outcomes, and other features that are most likely to lead to impaired waters. Such methods, when integrated into probability or other monitoring designs, should specifically enable EPA and the States to address the NRC recommendation.

ORD envisions the second dimension as one of diagnostic analysis to solve the “inverse problem”. That is, given evidence of biological or physicochemical impairment in surface waters, how does one infer the causes (stressor or suite of stressors) and the sources (e.g., current or historical discharges, point or nonpoint sources, anthropogenic or natural)? For example, if the observed benthic invertebrate indicators suggest aquatic impairment, what are the specific stressors and their related sources? And, given evidence of stressors in surface water, how does one infer the sources and their magnitudes? For example, if nitrogen levels exceed nutrient criteria, how does one infer the sources, their magnitudes, and transport pathways leading to the observed levels?

An array of data and tools will be investigated as approaches for both dimensions of the problem. Included among the approaches are water body and ecosystem classification schemes, landscape characterization, cause-effect modeling and experimental watershed analysis methods including gradient studies. Table 3 arrays the APG’s and APM’s proposed to meet this goal. Figure 6 shows the linkage and timing of the proposed Annual Performance Goals for this Long Term Goal. Note, again, that the structure of the APG’s illustrated in Figure 6 implies both the provision of relevant and necessary science and the application, or demonstration of the science.

A major, and perhaps overriding, challenge for this entire body of work is to provide robust methods that can be implemented by watershed managers and State Agencies within the expected operational constraints of limited data sets and analysis time frames.

Priorities include continued development of the science from this plan (e.g., stressor-response relationships and diagnostic indicators) and from other multi-year plans (e.g., Goal 4 Ecology Research) to support OW Stressor Identification Guidance. The expectation is that such guidance will be supported by an ongoing product stream of increasing complexity and robustness.

Progression over time is envisioned as moving from empirical methods that embed limited causality to robust and field-capable methods and models that provide robust causality and unambiguous source identification. ORD also envisions, pending resource availability, watershed demonstrations as part of interactive partnerships with EPA Regions and States.

### **Expected Impact and Outcomes**

A notable and potentially powerful outcome of research proposed to meet this long term goal is the prospect of inventing alternative but efficient and economical ways to implement major steps in the TMDL development process, especially in the listing and assessment phases (e.g., use of extrapolation techniques such as classification schemes). Because this goal speaks both to the NRC report on 303(d) listing decisions and to existing and proposed TMDL guidance on problem and source identification, reasonable expectations for outcomes include efficient, precise, and robust prescriptions for intervening to restore impaired waters, i.e., we can cure the patient only when we have diagnosed the illness.

Now, consider Long Term Goal 3 in more detail.

### **Long Term Goal 3. Provide the tools to restore and protect impaired aquatic systems and to forecast the ecological, economic, and human health benefits of alternative approaches to attain water quality standards**

#### **Summary of Research Questions and Approaches**

- What additions to models are most needed for the TMDL process? For habitat alteration? For nutrients? For suspended and bedded sediments? For pathogens? For toxic chemicals?
- What BMP's, treatment systems and restoration technologies remain as uncertain options for watershed management? For mixed land use watersheds? For habitat alteration? For nutrients? For suspended and bedded sediments? For pathogens? For toxic chemicals?
- How can classification schemes, modeling, scenario analyses, landscape classification, and economic projections be applied to provide alternatives for meeting water quality goals efficiently at multiple scales? What are the economic benefits of watershed management?

ORD envisions an approach for meeting the third long-term goal that also builds on prior work in both modeling and technology development but that shifts the focus of research from “pollutant loading and load reduction” to pollution prevention, multimedia modeling, and restoration approaches for watershed management. Priorities are proposed for “performance-based” technologies, increasing use of and anticipation for market-based risk management frameworks, and more efficient and cost-effective forecasting and modeling. Another feature of the proposed research is integration of economic data into watershed planning and implementation that will lead to a better understanding of both the costs and benefits of alternative ways to achieve water quality.

Table 4 arrays the APG’s and APM’s proposed to meet this goal. Figure 7 shows the linkage and timing of the proposed Annual Performance Goals for this Long Term Goal. Note, again, that the structure of the APG’s illustrated in Figure 7 implies both the provision of relevant and necessary science and the application, or, demonstration, of the science.

Priorities include the stressor-specific emphases common to Long Term Goals 1, 2, and 3 for habitat alteration, nutrients, suspended and bedded sediments, and pathogens, and toxic chemicals, while working to resolve remaining uncertainties for PBT’s and metals. The proposed priority sources and watershed types are intended to reflect both the weights illustrated in Figure 4 and in ORD’s understanding of the non-EPA research being conducted by other Federal and State agencies responding to other constituencies.

The recent TMDL NRC (June 2001) study also specifically challenged the Agency to address science needs in both the modeling and implementation strategies currently being deployed for topics under this long term goal. Adaptive management (watershed scale hypothesis-driven research with feedback monitoring) and increased use of uncertainty analysis in modeling and decision-making are notable and appropriate challenges.

### **Expected Impact and Outcomes**

The public rightly holds EPA accountable for the outcome of our collective efforts in research and operational activities to be measured as improvements in water quality. Simply put, the expectation is the formulation and implementation of solutions that work, are affordable, and that are sustainable in social, economic, and ecological terms. This outcome-based expectation provides the focus for research under this long-term goal.

If successful, the results from this research will enable States and watershed stakeholders to be more efficient in meeting process requirements (e.g., load allocations, implementation plans, load reductions, etc.) and, more importantly perhaps, develop linked socioeconomic and water quality management and policy strategies that lead to sustainable and sustained improvements in both environmental and economic well being.

Expected outcomes include moving from technology-based to performance-based approaches, full integration of biological and physicochemical factors, and decision-making that is fully informed by inherent variability and uncertainties.

Finally, consider the Long Term Goal 4 in more detail.

**Long Term Goal 4. Provide the approaches, methods and tools to assess the exposures and reduce the human health risks from biosolids contaminants for use by OW, States and others in updating biosolids guidance and regulations**

**Summary of Research Questions and Approaches**

- Do contaminants in biosolids pose a significant health risk to the public when applied in compliance with current regulations?
- What additional models, tools and methods are needed to identify, measure and assess aggregate exposure pathways and risks?
- What improved analytical techniques can be developed to adequately determine pathogen and priority toxic chemicals in or released from biosolids?
- What is the current state of management practices for biosolids production and application, and how can those be made more effective?

ORD envisions a program that addresses key issues identified in the 2002 NRC report: *“Biosolids Applied to Land: Advancing Standards and Practices.”* The key finding of that report was that the scientific basis for protecting human health needs to be updated. The science questions listed above are key to addressing this finding.

As dictated by the large number of uncertainties associated with the science questions, ORD is conducting several studies in FY03 and FY04 to better formulate the problem, including screening level risk assessments and field studies of biosolids composition, management techniques and releases to the environment. These initial studies will be used to better define research gaps and will support others in EPA in addressing the NRC findings.

Based on work in FY03 and FY04, ORD plans to identify more specific research that is needed to address the science questions. This research in FY04 and beyond may address the improvement of assessment methods and their application, analytical technique development, and further evaluation and/or development of biosolids management techniques. The biosolids research APGs and APMs beyond FY04 that are listed at the end of this plan are current ORD proposals and subject to change (see Table 5 and Figure 8).

**Expected Impact and Outcomes**

If successful, the results of this research will lead to a reduction of uncertainties about the impacts on the public near biosolids sites and provide alternatives for reduction of any health risks posed by biosolids land application. The research can support EPA and others in

determining if there are significant risks associated with current management of biosolids application. The research also supports decisions on what improved management techniques might be chosen.

## Resource Allocation Among the Long Term Goals

Table 2 illustrates the relative resource allocation among the Plan's Long Term Goals. This table was constructed by including all relevant resources including intramural accounting (personnel and related costs) and extramural accounting (funding for grants, cooperative agreements, and contracts).

The proposed resource shifts shown are modest, project trends to reflect priorities, and are consistent with the principle embedded in Figure 3. Precise and annual allocation of limited resources among essential components of the research will remain difficult and are subject to Agency priorities and contingencies; the guidance in the Table should inform the annual processes.

### Summary of the non-EPA research supportive of the LTG's

The process illustrated in Figure 1 is EPA and "State-centric" in that it describes the Agency's mandate under the Clean Water Act, as widely, but not exclusively, implemented by the States. It also invites interest from multiple groups and institutions, especially those serving constituencies with real or perceived liabilities for the action programs implemented by EPA and the States. Such groups advocate and support research programs in both the public and private sector. Among Federal natural resource management agencies, research programs are responsive to Department priorities, which are relevant to, if not overlapping with, ORD research. For example, the U.S. Department of Agriculture (USDA) has both natural resource management and Clean Water Act responsibilities (e.g., the U.S. Forest Service's multiple-use management of the National Forests). Also, the USDA responds to constituencies (e.g., animal producers and row-crop commodity groups) who advocate research to enable appropriate and effective responses to Clean Water Act programs. The U.S. Geological Survey (USGS) and National Oceanic and Atmospheric Administration (NOAA) are federal agencies charged with providing data and public information on surface water resources and marine fisheries. These agencies often view EPA as clients within the federal community and ORD often partners with them to leverage our respective missions, interests, and resources (e.g., coastal monitoring, surface water monitoring as part of field research projects, joint solicitations for competitive grants on HAB's and algal toxins). While common interests with the non-EPA research community are varied, and opportunities for meaningful and effective partnerships are acknowledged (and often

Table 2. Relative Resource Trends Among the Long Term Goals

Goal	FY03 Base % of total	FY10 Base % of total
LTG 1	53	40
LTG 2	16	20
LTG 3	31	40
LTG 4	TBD	TBD

implemented within Labs and Centers), the scope and intensity of such research has been implicitly integrated into the content and priorities of this proposed plan. Formal coordination is provided via standing and *ad hoc* working groups and committees within the prevailing Administration research coordinative mechanisms (e.g., the Committee on the Environment and Natural Resources (CENR) as configured by the White House Office of Science and Technology Policy).

A summary of how knowledge of the non-EPA research was factored into the proposed APG's and APM's is summarized below:

- ◆ ORD's National Center for Environmental Research (NCER) issues joint solicitations with NOAA, USDA, the Centers for Disease Control (CDC), and the National Science Foundation (NSF) on topics related to HAB's, pathogens in recreational waters, and CAFO's
- ◆ field and laboratory experimental work in pursuit of LTG's 1-4 are supplemented by Interagency Agreements with USGS, NOAA, TVA, USDA, and the U.S. Army Corps of Engineers.
- ◆ for LTG 3, ORD has set a priority on reducing uncertainties for urban and mixed land-use watersheds, and watersheds in transition from development pressures; completely forested and agricultural watersheds are largely the domain of USDA
- ◆ ORD will (and has to date) coordinate if not negotiate with relevant federal research and funding agencies in order to avoid unnecessary duplication
- ◆ a limited number of cooperative agreements with research universities are issued as part of the ORD Laboratory or Center research portfolio across the long term goals
- ◆ ORD proposes to integrate research from other Agencies and the academic community as a means to provide leadership in advice to the OW, Regions, States, and local agencies; a renewed interest in technology transfer is expected to focus on the long term goals as well
- ◆ Due to its long term involvement in biosolids research, ORD has a strong with a strong understanding of current biosolids research in the Office of Water and outside EPA. Outside research is being further evaluated by EPA to determine critical research needs. In addition, ORD is conducting collaborative research with USDA, States and others.

## **Concluding Notations for Current Resource Base**

EPA's mission to protect human health and the environment via the Clean Water Act is among the most mature and longstanding mandates entrusted to the Agency. Progress over the last thirty years is notable, even commendable. Much remains to be done; public support is strong, direct stakeholder interest and participation are growing, and the watershed approach is firmly established. Our continued progress and success depend on the continued dedication of ORD's and the Nation's researchers to resolve the increasingly complex and interacting factors that determine both biogeophysical response and human behavior in watersheds. The multi-year plan described herein is proposed as a framework for achieving the research components required to achieve measurable and measured improvement in water quality. Desirable, overall **outcomes** are as follows:

- ▶ impaired waters are accurately and efficiently identified and characterized
- ▶ causes and sources of stressors leading to impairments are made readily apparent
- ▶ all interested stakeholders will have robust and efficient tools at their disposal to assess the restoration requirements, evaluate their costs and feasibility, and project their optimum deployment
- ▶ locally developed and implemented systems to regulate or motivate actions are available
- ▶ water quality improvements from action programs are fully documented at reasonable costs
- ▶ water quality is sustained and maintained in a balanced fashion that reflects legislative mandates, reflects public and stakeholder interests, and that provides ecosystem and public health services for future generations.

### **Unfunded Priorities**

The decisions leading to the research described in this plan are intended to be largely strategic and to reflect the highest priorities with consideration for ORD workforce skills and Office of Water programmatic priorities. The challenges presented by the long term goals are daunting and merit a sustained research program. That said, a number of emerging issues and policy-relevant questions remain under-studied and must be integrated into the resource allocation process. Accordingly, this section of the Plan identifies a number of research areas and questions that remain largely unaddressed. As such, this section is intended to describe areas for which additional funding is needed.

In some cases, this section will also identify alternative priorities beyond those embedded in the research program that should be carefully weighed as annual budgets are developed. Progress in some areas should enable a different resource allocation than is now in force and hence these priorities are also candidates to displace lower priorities within the base program.

## **Issue 1 – economic benefits from water quality programs and rule-making**

**What are the economic benefits of meeting water quality goals and standards? What is the cost-effectiveness of the programs and approaches designed to achieve the goals and standards?**

The 305(b) reports and the 303(d) listed waters are evidence that failure to attain water quality goals and standards is widespread. From the perspective of an economist, it must be true that the benefits of achieving water quality goals are less than the costs and hence the lack of attainment. The reasons for this apparent condition are no doubt manifold and complex. Among the reasons must be the difficulty in assigning monetary benefits to “ecosystem conditions” that are typically not part of market transactions. Other reasons include uncertainties in the connection and relationship between management or program variables (e.g., nutrients reduction, BMP’s for nonpoint source controls, permit conditions for CAFO’s, among many others) and the water quality condition indicators (e.g., IBI’s, coastal hypoxia, fish abundance and species richness, among many others). Research is needed on non-market valuation methods, on cost-benefit methodologies, and on the translation of control/programmatic variables into benefits measures. This issue is made all the more urgent when one considers the nascent EPA Report on the Environment, which is expected to serve as the baseline for a sustained public communication of the EPA’s progress in achieving our mission.

## **Issue 2 – BMP effectiveness**

**What is the effectiveness of Best Management Practices as the conceptual and programmatic solution to meeting water quality goals?**

BMP’s were invented circa 1974 and have stood as the EPA policy to achieve nonpoint source pollutant control. Over this time period, the BMP research and implementation communities have provided an array of BMP’s, design and operational procedures, and models that are intended to implement EPA policies. The context and “design parameters” for BMP’s have not changed.

Since 1974, the measures and indicators of ambient water quality have evolved to accommodate more complex and biologically-based outcomes. Non-attainment of water quality goals is often attributed to failure to meet these more relevant indicators of ecosystem health. This trend has resulted in less ability to know or estimate the effectiveness of the BMP policy and the cumulative investments in that policy.

Research is needed to develop new approaches to empirically documenting the effectiveness of BMP’s in meeting biologically-derived water quality goals. New models are urgently needed to forecast outcomes from BMP’s at different scales.

## **Issue 3 – use attainability and adaptive management**

**What additional knowledge is needed to engage in adaptive management of the waters of the U.S. as an outcome-oriented approach to achieving Clean Water Act goals?**

Water quality standards, when properly constructed and met, ensure that the waters of the U.S. provide the ecosystem goods and services required to achieve the designated use. The “designated use” decisions reflect long-standing public expectations and regulatory bodies at the State and Federal level have been reluctant to call for “use attainability” as a scientific issue.

Arguably, if the scientific and policy communities respond to the call for “increased use of adaptive management” as expressed in the NRC study on TMDL’s, then the interaction among standards, designated uses, and the “attainability” of both must be better understood.

Research is needed to provide more focus on this use attainability issue so that the scientific basis for possible policy developments will exist.

**Issue 4 – ecological and human health links**

**What are the scientific links and interactions among ecological and human health endpoints and benefits vis-a-vis the Clean Water Act?**

The reality that the Nation often fails to meet the water quality goals of the Clean Water Act begs many questions. Arguably, one science issue is the lack of understanding available that links human health benefits to ecological health and biological integrity and sustainability. That said, it is very clear that much of the early success in water pollution control came from actions driven by public health goals, particularly reduction in water-borne diseases.

There is a need to re-visit this vital link between water quality to protect ecosystems and public health and well-being.

TABLE 3

LONG TERM GOAL 1: Provide the approaches and methods to develop and apply criteria for habitat alteration, nutrients, suspended and bedded sediments, pathogens and toxic chemicals that will support designated uses for aquatic ecosystems

ANNUAL PERFORMANCE GOALS AND MEASURES		YEAR	LAB/ CENTER
<b>HABITAT ALTERATION</b>			
<b>APG 8 (GPRA) - Provide <i>demonstration</i> stressor-response relationships and/or models linking loss and alteration of habitat to selected fish, shellfish, and wildlife endpoints.</b>		<b>2006</b>	<b>ORD</b>
APM	Report on Penaeid shrimp dependence on seagrass habitat	2003	NHEERL
APM	Report on finfish dependence on seagrass and oyster reef habitats	2003	NHEERL
APM	Prototype watershed-stream network model for Pacific Salmon	2004	NHEERL
APM	Report characterizing relationships between multiple habitat types and economically valuable fish at the scale of an estuarine shoreline	2004	NHEERL
APM	Report characterizing the relationship between habitat in stream networks and salmon-native fish for coastal Oregon watersheds	2005	NHEERL
APM	Report characterizing the relationship between alteration of vegetated habitats and nekton use of those habitats	2006	NHEERL
APM 58 GPRA	Report characterizing relationships between abundance, quality, and arrangement of various habitat types and selected biotic assessment endpoints in coastal systems	2006	NHEERL
<b>APG - Provide stressor-response relationships and/or models linking loss and alteration of habitat to selected fish, shellfish, and wildlife endpoints</b>		<b>2006</b>	<b>ORD</b>
APM	Report on habitat suitability indices to support population models for projecting relative risks of multiple stressors including toxic chemicals and habitat alteration to common loons	2004	NHEERL

APM	Report on indices of watershed integrity based on land use/land cover and relationships to fish (e.g., salmon, pike, and/or others)	2005	NHEERL
APM	Reports characterizing the relationship between landscape-scale habitat mosaics and native fish by wetland type in the Great Lakes	2005	NHEERL
APM	Final report characterizing relationships between abundance, quality, and arrangement of various habitat types and selected biotic assessment endpoints in coastal systems	2006	NHEERL
<b>APG - Provide suites of habitat alteration - biological response relationships and generalization/extrapolation schemes suitable for developing broad-scale habitat criteria for streams and coastal systems, and provide approaches for evaluating combined effects of habitat alteration and other stressors</b>		<b>2008</b>	<b>ORD</b>
APM	Report on the ecological consequences of marine derived nutrients and nutrient enrichment for aquatic biota and stream habitat quality, with an emphasis on salmon and native fish	2004	NHEERL
APM	Initial report on food web-mediated vs. habitat-based alteration of fish communities from field studies across a representative group of Great Lakes coastal wetlands	2006	NHEERL
APM	Report on estimating the feasibility of restoring currently at-risk wild salmon habitat through use of replacing lost marine derived nutrients and the likely ecological side effects of such additions	2006	NHEERL
APM	Regional models of landscape influence of salmon/native fish in the Pacific Northwest and native fish in Great Lake coastal wetlands	2007	NHEERL
APM	Empirical and model-based evaluation of effectiveness of habitat and nutrient criteria as protective of the health of aquatic life in Great Lakes coastal wetlands	2008	NHEERL
APM	Report on the interactions between stream nutrients and habitat alteration on water quality and aquatic life	2008	NHEERL
APM	Synthesized quantitative species-habitat relationships suitable for developing regional habitat-based biocriteria for shorelines, lakes, and estuaries	2008	NHEERL

NUTRIENTS			
<b>APG 15 GPRA) - Complete the framework for including dissolved oxygen and other receiving water thresholds into watershed management for nutrients</b>		<b>2003</b>	<b>ORD</b>
APM 201 GPRA	Report on the effects of nutrient enrichment on coastal phytoplankton communities	2003	NHEERL
APM	Propose classification scheme for predicting sensitivity of coastal receiving waters to effects of nutrients on DO	2003	NHEERL
APM	Provide minimum dissolved oxygen requirements for a suite of the important marine organisms in the Atlantic, Pacific, and Gulf of Mexico coastal waters of the U.S.	2003	NHEERL
<b>APG - Provide the scientific foundation for establishing site-specific nutrient threshold criteria to protect estuarine SAVs and freshwater organisms</b>		<b>2007</b>	<b>ORD</b>
APM	Report on the correlation of water quality with SAV change	2003	NHEERL
APM	Report on environmental requirements of three main species of seagrasses	2004	NHEERL
APM	Development of stress-response model for <i>Zostera marina</i> in Pacific Northwest and validation of stress-response model for <i>Thalassia testudinum</i> .	2004	NHEERL
APM	Development of empirical load-response models for <i>Zostera marina</i> in NE U.S.	2004	NHEERL
APM	Report on a spatial approach to assessing nutrients and nutrient criteria at landscape and watershed scales	2005	NCEA
APM	Report on an approach to refining regional nutrient criteria on the basis of adverse effects to faunal assemblages.	2005	NCEA
APM	Development of load-response models for estuaries of Pacific Northwest and Gulf Coast, and validation of stress-response model for <i>Zostera marina</i> in NE U.S.	2005	NHEERL
APM	Propose classification scheme for predicting sensitivity of coastal receiving waters to the effects of nutrients on SAV	2005	NHEERL

APM	Report on the empirical and numeric models for SAV	2006	NHEERL
APM	Report on a classification scheme for grouping coastal receiving waters based on sensitivity to nutrients	2007	NHEERL
<b>APG - Provide scientific foundation for development and application of quantitative measures of food web attributes that are sensitive to ecological changes associated with nutrient enrichment</b>		<b>2007</b>	<b>ORD</b>
APM	Report on the sensitivity of food web responses to nutrient loading in coastal systems	2004	NHEERL
APM	Propose classification scheme for coastal receiving waters based on food web sensitivity to nutrients	2005	NHEERL
APM	Report on coastal wetlands of the Great Lakes: Discrimination of trends in food web response as a function of nutrient loading and ecosystem classification factors	2005	NHEERL
APM	Report on empirical and numeric models for food webs	2006	NHEERL
APM	Report on the parameterization of food web models	2007	NHEERL
APM	Report on classification scheme for grouping coastal or lake receiving waters based on sensitivity to food web alterations	2007	NHEERL
APM	Final report on Great Lake coastal wetlands to define food web-nutrient response thresholds	2007	NHEERL
<b>APG - Provide the scientific foundation and information for the development of a water quality model of the Gulf of Mexico hypoxic zone</b>		<b>2008</b>	<b>ORD</b>
APM	Field cruise report for 2002-2004 for hypoxia surveys in the Gulf of Mexico	2005	NHEERL
APM	Report on the conditions and seasonal trends of water quality in the Gulf of Mexico hypoxic zone	2006	NHEERL
APM	Report on the database of environmental information necessary to develop the water quality model of the Gulf of Mexico hypoxic zone	2007	NHEERL

<b>BIOCRITERIA/BIOASSESSMENT</b>			
<b>APG - Demonstrate bioassessment methods to establish biocriteria for a range of designated uses in freshwater systems within Eastern US rivers</b>		<b>2004</b>	<b>ORD</b>
APM	Report on newly developed and review of existing biocriteria and bioassessment tools for rivers and streams in MidAtlantic	2004	NERL <i>EERD</i>
APM	Report on newly developed and review of existing bioassessment tools and biocriteria for New England	2004	NERL <i>EERD</i>
APM	Statistical/analytical guidance, including case studies, to help states choose scientifically sound methods for setting biocriteria in the eastern U.S.	2004	NERL <i>EERD</i>
<b>APG - Demonstrate bioassessment methods to establish biocriteria for a range of designated uses in freshwater systems within Mid-Western U.S. rivers</b>		<b>2006</b>	<b>ORD</b>
APM	Report comparing differences among invertebrate data collected using EMAP, NAWQA and OEPA methods in large rivers	2003	NERL <i>EERD</i>
APM	Report on the association among invertebrates and habitat indicators for large rivers in the midwest	2004	NERL <i>EERD</i>
APM	Report on prototype indicators of condition for deep river fish assemblages	2004	NERL <i>EERD</i>
APM	Guidance Document on the Bioassessment of Large Rivers: Concepts, Approaches and Theory	2005	NERL <i>EERD</i>
APM	Report on the field and laboratory performance characteristics of a new sampling method for riverine macroinvertebrate assemblages	2005	NERL <i>EERD</i>
APM	Report on the comparison of random site selection and systematic site selection for assessment of 305(b) reporting segments of the Ohio River	2006	NERL <i>EERD</i>
NEW APM	Report that compares aquatic life criteria , direct bioassay results and bioassessments of macroinvertebrates or fish assemblages; to examine the protectiveness of chemical criteria in streams and estuaries	2006	NCEA

<b>PATHOGENS/INDICATORS OF FECAL CONTAMINATION</b>			
<b>APG Provide a rapid means of measuring recreational water quality and an assessment of the health risks associated with swimming in waters of varying quality</b>		<b>2007</b>	<b>ORD</b>
APM	Report on faster, simpler indicator method for fecal contamination	2003	NERL <i>MCEARD</i>
APM	Produce a report on the pilot studies and preliminary statistical analyses used to evaluate the beaches epidemiological data	2003	NHEERL/ NERL
APM	Report on the evaluation of water quality indicators and health outcomes for beaches evaluated in FY03	2004	NHEERL/ NERL
APM	Report on determination of exposure characteristics(e.g., activity patterns, ingestion rates) for recreational users	2004	NERL <i>MCEARD</i>
APM	Report on fecal indicator monitoring protocols for different types of recreational waters	2004	NERL <i>MCEARD</i>
APM	An evaluation of alternative indicators of recreational water safety for tropical regions	2004	NCER
APM	An evaluation of the risk posed by exposure to pathogens in the swash zones (sand/water interface regions) of recreational beaches	2004	NCER
APM	Report on the evaluation of water quality indicators and health outcomes for beaches evaluated in FY04	2005	NHEERL/ NERL
APM	Report on the evaluation of water quality indicators and health outcomes for beaches evaluated in FY05	2006	NHEERL/ NERL
APM	Deliver a rapid method (less than 2 hours to results) for monitoring beach water quality that provides the best relationship to the frequency of swimming-associated illness	2007	NERL/ NHEERL
APM	Report describing swimming associated illness and the quality of water measured using a rapid indicator method	2007	NHEERL/ NERL
<b>TOXIC CHEMICALS</b>			
<b>APG - Provide a summary of the available methods to set risk-based water and sediment quality criteria for toxic chemicals</b>		<b>2003</b>	<b>ORD</b>

APM	Describe a framework for water quality criteria for nonbioaccumulative chemicals based on risks to aquatic organisms	2003	NHEERL
<b>APG - Provide methods for extrapolating chemical toxicity data across exposure conditions and across endpoints, life stages, and species which can support assessment of risks to aquatic life and aquatic-dependent wildlife for chemicals with limited data</b>		<b>2006</b>	<b>ORD</b>
APM	Acute-to-chronic estimation (ACE) user guide and software	2003	NHEERL
APM	PBTK/TD model for predicting individual effects on birds from chronic mercury exposure to facilitate cross-species extrapolation of toxicity responses	2005	NHEERL
APM	Report on evaluating importance of dietary route of exposures to aquatic risk assessments for metals	2006	NHEERL
<b>APG - Provide approaches for evaluating the relative and cumulative risks from toxic chemicals, with respect to risks from nonchemical stressors, on populations of aquatic life and aquatic-dependent wildlife at various spatial scales</b>		<b>2008</b>	<b>ORD</b>
APM	Report regarding assessment of risks to aquatic organisms from combined exposure to polycyclic aromatic hydrocarbon mixtures and ultraviolet radiation in natural systems	2005	NHEERL
APM	Benthic Macroinvertebrate indicators of pesticides in stream water and sediment	2006	NERL <i>EERD</i>
APM	Develop and test an approach for assessing risks of multiple stressors to wildlife populations in spatially-diverse landscapes	2008	NHEERL
<b>MULTIPLE STRESSORS</b>			
<b>APG 111 (GPRA) - Provide methods for characterizing population-level risks of multiple stressors to aquatic life and aquatic-dependent wildlife for use in developing improved criteria to protect water quality</b>		<b>2005</b>	<b>ORD</b>
APM	Two final reports (and a database) comparing and analyzing the quantitative dose-response relationship from recently published studies of aquatic and aquatic-associated wildlife	2003	NCEA

APM 59 GPRA	Develop and test simple population models that project the relative risks of multiple stressors (toxics, habitat alterations) to piscivorous birds	2004	NHEERL
APM	Methods for characterizing the exposure and response of sensitive ecosystems components to pesticides or nutrient stress using biomonitors and stable isotope ratios of nitrogen	2005	NCEA
<b>OTHER STRESSORS</b>			
<b>APG Data and analysis are made available to help OW characterize the potential risk of PPCPs to impair waterbodies and evaluate the need for human health and ecological criteria (i.e., MCLs and AWQC)</b>		<b>2006</b>	<b>ORD</b>
APM	Toward a green pharmacy - Cradle to cradle stewardship of drugs for minimizing their environmental disposition while promoting human health	2004	NERL
APM 281	Concentration, detection and measurement of four widely-prescribed pharmaceuticals at three municipal wastewater treatment plants using POCIS and LC/MS.	2005	NERL
APM 282	Levels of synthetic musks in municipal wastewater for estimating biota exposure in receiving waters	2005	NERL
APM 283	Closed-loop stripping of synthetic musk compounds from fish tissues and analysis by GC/MS/SIM.	2005	NERL
APM	<b>"Virtual" Symposium: State of the Science — PPCPs as Environmental Pollutants</b>	2005	NERL
APM	Review of Environmental forensic techniques (e.g., high resolution MS and ICE software) over the last decade. Review article.	2005	NERL
APM	Sensitive Hemoglobin Adduct Methodology Applied to the Terminal Valine Proteins in Carp as an Indicator of Environmental Exposure. Journal article.	2005	NERL
APM	Applications of Advanced Mass Spectrometric Techniques to Defining Environmental Exposures. Internal report.	2006	NERL

APM	Improved detection methods for, and occurrence levels of, pharmaceuticals and personal care products in effluents, surface waters, treated drinking water and groundwaters [Brownawell, Graham, Weinberg, Roberts]	2006	NCER
APM	An evaluation of how effective wastewater treatment practices are at decreasing levels of pharmaceuticals and antiseptics in drinking water [Brownawell Graham, Roberts]	2006	NCER
APM	An evaluation of conferred antibiotic resistance in microbial communities resulting from pharmaceuticals and personal care products in the water [Weinberg, Graham]	2006	NCER
APM	An evaluation of the influence of amphiphiles on the fate and transport of pharmaceuticals in the environment. [Kibbey]	2006	NCER
APM	An evaluation of the ecotoxicity of selective serotonin reuptake inhibitors (SSRIs) in wastewaters, effluents, & surface waters & the ecotoxicity of fluoroquinolone antibiotics via lab- & field-scale systems [Armbrust, Graham]	2006	NCER

**TABLE 4**

LONG TERM GOAL 2: Provide the tools to assess and diagnose sources and causes of impairment in aquatic systems.

ANNUAL PERFORMANCE GOALS AND MEASURES		YEAR	LAB/ CENTER
<b>APG 16 (GPRA) - Provide the scientific foundation and information management scheme for the 303(d) listing process including a classification framework for surface waters, watersheds, and regions to guide problem formulation</b>		<b>2003</b>	<b>ORD</b>
APM 202 GPR A	Classification frameworks for geographic regions and at the watershed, water body and habitat scale	2003	NHEERL
<b>APG - Provide first generation diagnostic methods, including stressor identification (SI) methods, for causal linkage of observed major classes of single stressors and biological indicators to stressors in freshwater and marine systems; scale the methods to States and watershed organizations</b>		<b>2005</b>	<b>ORD</b>
APM	Develop molecular diagnostic techniques to identify Pfiesteria complex organisms and better delineate their distribution. And identify, purify, and chemically characterize their toxins (R82-6791; R82-7084; & R82-6655)	2003	NCER
APM	Develop a method for cryopreserving strains of Pfiesteria complex organisms and establish over 50 culture isolates to be available to the scientific community (R82-6793)	2003	NCER
APM	Model of the biophysical interactions Gymnodinium breve red tides with its chemical and physical habitat and determine the production, occurrence, fate and effects of brevetoxins in the environment during and after blooms. (82-6792 & 82-7085)	2003	NCER
APM	Guidance on whole sediment Toxicity Identification Evaluation (TIE) procedures	2003	NHEERL

APM	Publication of the newly identified mechanisms of lesion initiation and the contributory environmental and biological conditions required for lesion development & progression in fish following exposure to PCO (Pfiesteria complex organisms) (R82-8224 & Shields)	2004	NCER
APM	Landscape Atlas for pesticides, nutrients and sediments for streams in the Mid-Atlantic coastal plain	2004	NERL <i>ESD</i>
APM	Application of coastal watershed and estuarine/lacustrary classification schemes to predict probability of impairment based on Great Lakes and Gulf of Mexico regional case studies	2005	NHEERL
APM	Guidance on and user-friendly interfaces for derivation of diagnostic indicators for individual stressors	2005	NHEERL
<b>Equip EPA Regions, States and Tribes with knowledge, skills and tools to determine the causes of impairments for freshwater and coastal systems required in various regulations</b>		<b>2008</b>	<b>ORD</b>
APM	Case study implementation plans for multivariate approaches to community data analysis to apportion cause among stressors in coastal ecosystems	2003	NHEERL
APM	Case study demonstrating the Stressor Identification Process that identifies the causes of biological impairment in the nation's waterbodies	2003	NERL/ NCEA
APM	Evaluate the efficacy of AFLP technology as a fast and reproducible molecular tool to discriminate among species of enterococci	2004	NERL
APM	Report on methods/indicators for determining when biological impairments of rivers and streams are due to sediment loads	2004	NERL <i>EERD</i> / NCEA
APM	Report on potential of swine CAFOs to contribute pathogens, EDCs and other contaminants of concern to ground water <i>(Also included in LTG 3 2007 APG on CAFOs)</i>	2004	NRMRL <i>GWERD</i>
APM	Determine the nature and concentration of aquatic stressors released from animal agriculture operations in the form of aerosols <i>(Also included in LTG 3 2007 APG on CAFOs)</i>	2005	NRMRL <i>LRPCD</i>

APM	Application and evaluation of molecular methods (AFLP and others) to discriminate between human and non-human sources of fecal indicator bacteria	2005	NERL
APM	Report on methods/indicators for determining when biological impairments of rivers and streams are due to toxics	2005	NERL <i>EERD</i> / NCEA
APM	Training and problem solving workshop: determining the causes of biological impairment, the scientific basis, tools and applications applied to state-listed 303(d) streams	2005	NERL/ NCEA
APM	Produce landcover/landuse digital database for watersheds in southwest US	2005	NERL <i>ESD</i>
APM	Make landcover/landuse digital database for watersheds in southwest US publically available thru website	2006	NERL <i>ESD</i>
APM	Produce landscape atlas for pesticides and nutrients in Midwest streams	2006	NERL <i>ESD</i>
APM	Implementation plans for extension of case studies from coastal ecosystems into their watersheds	2006	NHEERL
APM	Report on the importance of subsurface transport in the release of nutrients, pathogens, and antibiotics into the watershed ( <i>Also included in LTG 3 2007 APG on CAFOs</i> )	2006	NRMRL <i>GWERD</i>
APM	Case study determining the causes of biological impairment in an urban setting with non-point source impacts so that states and tribes will have prototypes to facilitate completion of TMDL's.	2006	NERL/ NCEA
APM	Watershed Academy website training for causal analysis	2006	NERL/ NCEA
APM	Publication of an in situ method for determining growth rates of natural populations of <i>Karenia brevis</i> (formerly <i>G. breve</i> ), utilizing radiolabeling of the biomarker pigment gyroxanthin (R82-9369)	2006	NCER
APM	Publication of a behavioral model for <i>G. breve</i> based on a characterization of the chemotaxis of the organism obtained by using <i>G. breve</i> Population Mimics (GBPMs) as Lagrangian drifters (R82-9370)	2006	NCER
APM	Publication presenting the influence of grazing pressure and viral activity on the dynamics of blooms caused by harmful dinoflagellates and algae (R82-9366 & R82-9367)	2006	NCER

APM	Publication of an evaluation of 38-year Narragansett Bay Time Series (NBTS) data to discern long-term patterns and variability in blooms of representative HAB species due to the effects of meteorological, climatic, physical, chemical and biological parameters (R82-9368)	2006	NCER
APM	Publication presenting a suite of microsatellite markers for use as tools to link diversity and structure of isolates of <i>K. brevis</i> with the physiological and ecological bases of bloom formation (R830413)	2007	NCER
APM	Publication of an assay to identify a nitrogen-regulated enzyme in <i>Alexandrium</i> for use as a new tool for identifying and monitoring nitrogen nutrition in field populations of harmful algae (R83-0415)	2007	NCER
APM	Publication of an evaluation of the physiology and ecology of macroalgae to identify different combinations of factors that lead to bloom formation and the potential for herbivores to control these blooms (R83-0414)	2007	NCER
APM	Simulation of key stressor interactions with generic ecosystem models using sensitivity analysis to define the range of stressors and stressor combinations under which nonadditive interactive effects will occur	2007	NHEERL
APM	Evaluate the DNA-based technology in impaired watersheds impacted by fecal contamination from diverse sources under a range of temporal (different flow dynamics, after strong rain episodes) and spatial (distance from the source, water vs. sediment) variability	2007	NERL
APM	Produce landscape atlas for pesticides and nutrients in California streams	2007	NERL <i>ESD</i>
APM	Collection of case studies determining the causes of biological impairment, the scientific basis, tools and applications toward improving stream quality.	2007	NERL/ NCEA
APM	Report on methods/indicators for diagnosing when biological impairments of rivers and streams are due to stressors associated with habitat alteration	2007	NCEA/ NERL
APM	Case study focusing on the special needs to perform causal analysis in biologically impaired large rivers.	2008	NERL/ NCEA

**TABLE 5**

LONG TERM GOAL 3: Provide the tools to restore and protect aquatic systems and to forecast the ecological, economic, and human health outcomes of alternative solutions

ANNUAL GOALS AND PERFORMANCE MEASURES		YEAR	LAB/ CENTER
<b>APG Provide updated models for stormwater management, and for allocating suspended solids and sediment loads, and related uncertainties for mixed land use watersheds.</b>		<b>2003</b>	<b>ORD</b>
APM	Report on GSTARS predictive model for sediment transport for use in TMDL watershed assessments for protecting aquatic ecosystems from siltation	2003	NERM <i>ERD</i>
APM 172	Provide States and watershed managers a document on managing pathogen contamination in the urban watersheds with information on health effects, detection methods and best management practices to meet TMDL requirements	2003	NRMRL <i>WSWRD</i>
APM 173	Update Storm Water Management Model (SWMM) for use by states, utilities and consulting firms in allocating pollutants in urban watersheds to meet TMDL requirements	2003	NRMRL <i>WSWRD</i>
APM	Develop and verify a numerical model for sediment oxygen demand exerted by organic material in the sediments and nitrogen and methane production under aerobic and anaerobic conditions at the sediment-water interface	2003	NRMRL <i>LRPCD</i>
<b>APG Provide indicators, monitoring strategies, and guidance for determining the effectiveness of Best Management Practices (BMP's) in meeting water quality goals.</b>		<b>2004</b>	<b>ORD</b>
APM 144	Develop a strategy to evaluate BMP performance via molecular based methods in watersheds impaired by fecal contamination	2004	NRMRL <i>WSWRD/</i> <i>LRPCD</i>
APM	Provide guidance on indicator selection and monitoring strategies for evaluating effectiveness of BMPs	2004	NRMRL <i>WSWRD</i>
APM 142	Report to the states, regions and program offices on methods to evaluate wet pond design effectiveness to control sediments and nutrients	2004	NRMRL <i>WSWRD</i>
APM	Develop an innovative BMP filter fence for sediment control to address inefficiencies with current practices at construction sites	2004	NRMRL <i>WSWRD</i>

APM 148	Report on microbial source tracking and its utilization to identify sources and measure the effectiveness of mitigation measures in waters impaired due to microbiological contamination	2004	NRMRL <i>WSWRD</i>
APM	Report on BMP performance data for controlling nutrients, suspended solids and sediments, and flow variations within urban watersheds and identifying information/research gaps	2004	NRMRL <i>WSWRD</i>
<b>APG Complete at least three (3) demonstrations of updated models for stormwater management, suspended solids, sediment, and nutrients to meet water quality objectives.</b>		<b>2005</b>	<b>ORD</b>
APM 137	Decision support tool for a lake/reservoir based on system assimilative capacity <i>Linkage to Goal 4 Ecological Research</i>	2004	NRMRL <i>GWERD</i>
APM 175	Prepare a document for use by states to assist in modeling risk management options and restoration measures in water bodies impaired due to suspended solids and sediment	2004	NRMRL <i>LRPCD</i>
APM	New sediment modeling protocol for instream processes	2004	NERL <i>ERD</i>
APM	Report demonstrating the effectiveness of applying stormwater structural BMPs as a tool to address sediment TMDL's	2005	NRMRL <i>WSWRD</i>
APM	Report to states, regions, and program offices demonstrating the use of time series analysis to identify non-point source impacts	2005	NRMRL <i>LRPCD</i>
APM	Report to states and program offices on the performance of models (risk management options and restoration measures) to meet water quality objectives for nutrients and sediments	2005	NRMRL <i>LRPCD</i>
APM	Report on the application of the updated Storm Water Management Model (SWMM) to predict drainage from alternative systems as a tool to assist in meeting TMDL requirements	2005	NRMRL <i>WSWRD</i>
APM	Technical outreach for new spatial grids of storm erosive power (R-factor and EI-30) for use in innovative landscape indicator development and the Revised Universal Soil Loss Equation	2005	NERL <i>ESD</i>
APM	Report describing processes controlling oxidation state in subsurface environments and related controls on nitrogen fate	2005	NERL <i>ERD</i>

APM	Report describing factors and processes controlling the fate of nutrients in streams	2005	NERL <i>ERD</i>
APM	Documentation of linked TMDL modeling system for nutrients	2005	NERL <i>ERD</i>
<b>APG Provide at least six (6) reports of performance data and information for controlling nutrients, suspended solids, sediments, pathogens, toxic chemicals (metals and PBTs), and flow variations urban and rural watersheds.</b>		<b>2006</b>	<b>ORD</b>
APM	Determine effectiveness of field application of clays to mitigate HABs NCER & NHEERL (CR-82-7091)	2003	NCER
APM (EDC-177)	Report on the stressor reduction (pathogen, EDC, antibiotic, and airborne nitrogen, particulate and pathogens) achievable using existing manure management practices at CAFOs	2004	NRMRL <i>LRPCD</i>
APM	Provide a method to identify areas within mixed-use watersheds most susceptible to channel instability and erosion as a tool to drive restoration prioritization for waterbodies impaired due to suspended solids and sediments	2004	NRMRL <i>WSWRD</i>
APM 146	Guidance document on Best Management Practices (BMP) for sewer solids management	2004	NRMRL <i>WSWRD</i>
APM	Report on BMP performance (including effectiveness/cost of constructed wetlands) for controlling nutrients, suspended solids and sediments, within mixed land-use watersheds	2006	NRMRL <i>LRPCD</i>
APM	Report on placement of BMP's in urban-watersheds to meet water quality goals	2006	NRMRL <i>WSWRD</i>
APM	Evaluation of the effectiveness of watershed management for suspended solids and sediments in controlling excess turbidity and the resulting biotic degradation in receiving waters	2006	NRMRL <i>LRPCD</i>
<b>APG – Provide State of the Science Synthesis and Application Approaches for Managing Risks from CAFO's</b>		<b>2007</b>	<b>ORD</b>
APM	Report on potential of swine CAFOs to contribute pathogens, EDCs and other contaminants of concern to ground water (Also included in LTG 2 2008 APG)	2004	NRMRL <i>GWERD</i>
APM	Determine the nature and concentration of aquatic stressors released from animal agriculture operations in the form of aerosols (Also included in LTG 2 2008 APG)	2005	NRMRL <i>LRPCD</i>

APM	Report on the importance of subsurface transport in the release of nutrients, pathogens and antibiotics into the watershed ( <i>Also included in LTG 2 2008 APG</i> )	2006	NRMRL <i>GWERD</i>
APM	Report on CAFO pollution prevention opportunities and a framework for successful implementation	2006	NRMRL <i>STD</i>
APM	Report on lifecycle assessment/sustainability evaluations of CAFOs including thresholds at which animal density begins to impair watersheds	2006	NRMRL <i>STD</i>
APM	Capstone report on the use of natural and constructed wetlands for the management of environmental stressors	2007	NRMRL <i>LRPCD</i>
APM	Capstone report on methods to reduce environmental risk from synthetic and natural hormones, pathogens and nutrients from CAFO manure management practices	2007	NRMRL <i>LRPCD</i>
<b>APG Provide at least seven (7) key reports, updated models, and data bases for allocating and managing suspended solids, sediment, pathogen, nutrients, and toxic chemical (metals and PBTs) loads among all sources in mixed land-use watersheds.</b>		<b>2007</b>	<b>ORD</b>
APM	TMDL database for sediments, nutrients, & organic carbon in the South Fork Broad River	2003	NERL <i>ERD</i>
APM	Database on pathogen indicators in the South Fork Broad River	2004	NERL <i>ERD</i>
APM	Visual Beach Model adapted to coastal, riverine, and lake systems	2005	NERL
APM	Report to states and program offices on the performance of models (risk management options and restoration measures) to meet water quality objectives for nutrients, sediments, pathogens and toxic chemicals	2007	NRMRL <i>LRPCD</i>
APM	Report on the field validation of the updated Stormwater Management Model to predict pollutant loadings to meet TMDL requirements	2007	NRMRL <i>WSWRD</i>
APM	Report on a state-of-the-science meeting on progress made in the restoration of water bodies impaired by key stressors	2007	NRMRL <i>LRPCD</i>

APM	Report that outlines improvements made to existing models to predict reductions of key stressors (nutrients, pathogens, toxics and clean sediments) in water bodies and improvement in biological integrity in mixed land-use watersheds and identify research gaps	2007	NRMRL <i>LRPCD</i>
<b>APG Demonstrate the application of innovative wet weather flow technologies in urban watersheds regulated under the National CSO Control Policy and SSO Programs</b>		<b>2007</b>	<b>ORD</b>
APM	Report demonstrating a Real Time Control system to maximize storage of wet weather flows in an urban sewer system to minimize CSOs/SSOs and meet the National CSO Policy	2005	NRMRL <i>WSWRD</i>
APM	Report on using/demonstrating CSO pollution control methods/concepts for urban stormwater pollution control	2005	NRMRL <i>WSWRD</i>
APM	Report on emerging engineering practices applying CSO pollution control methods/concepts for SSO pollution control	2005	NRMRL <i>WSWRD</i>
APM	Report on computer tools for predicting rainfall dependent infiltration/inflow in sanitary sewer systems and SWMM EXTRAN modeling analysis for SSO control planning	2006	NRMRL <i>WSWRD</i>
APM	Report on emerging engineering practices for the application of urban stormwater management techniques for CSO pollution control	2006	NRMRL <i>WSWRD</i>
APM	Report demonstrating a vacuum flushing system to remove sediments in an urban combined sewerage system	2007	NRMRL <i>WSWRD</i>
APM	Develop a manual on new sewer design methodology for preventing sewer solids deposition during dry-weather low-flow periods in combined and sanitary sewerage systems	2007	NRMRL <i>WSWRD</i>
<b>APG Demonstrate the application of models, landscape characterization methods, and economic analyses to formulate alternative approaches for protecting and restoring water quality and critical habitats and to forecast the ecological, economic, and human health outcomes of the alternatives</b>		<b>2008</b>	<b>ORD</b>
APM	Report on selected methods for integrating ecological risk assessment and economics to support watershed decision making	2003	NCEA

APM	GIS and landscape models to evaluate effectiveness of BMPs (case studies)	2006	NERL <i>ESD</i>
APM	Final methods for integrating ecological risk assessment and economics to support water body uses, water quality standards, and TMDL's	2007	NCEA
APM	Economic analysis of changes to human and ecological risk due to specific management alternatives	2008	NCEA
APM	Produce landscape indicator "tool box" to forecast impacts from pesticide use strategies	2008	NERL <i>ESD</i>
APM	Provide to the regions a framework for evaluating whether a TMDL restoration will be effective to restore water quality in the urban watershed.	2008	NERL/ NRMRL <i>WSWRD</i>
<b>APG Demonstrate proof-of-concept integrated assessments for allocation of restoration resources to support water quality standards attainment within the context of relevant socioeconomic factors and ecological integrity.</b>		<b>2010</b>	<b>ORD</b>
APM	Develop and deliver a methodology for economic evaluation of West Virginia watershed ecological restoration including market and non-market costs and benefits <i>Linkage to Goal 5 Pollution Prevention and New Technologies MYP</i>	2005	NRMRL <i>STD</i>
APM	Ecological evaluation of West Virginia watershed restoration as a basis for environmental decision making	2005	NHEERL
APM	Evaluation of watershed-based classification and assessment for State of West Virginia as a framework for watershed restoration decisions	2005	NHEERL
APM	Report on the use of ecological and economic evaluation as a basis for environmental decision making in West Virginia watershed ecological restoration.	2008	NHEERL Lead NRMRL, Support <i>STD</i>
APM	Report on the demonstration of ecological analysis/cost-benefit analysis as an approach to make more integrated resource management decisions in watershed ecological restoration in West Virginia to meet water quality standards	2010	NHEERL, Lead NRMRL, Support <i>STD</i>

**TABLE 5**

LONG TERM GOAL 4: Provide the approaches, methods and tools to assess the exposures and reduce the human health risks from biosolids contaminants for use by OW, States and others in updating biosolids guidance and regulations.

<b>ANNUAL GOALS AND PERFORMANCE MEASURES</b>		<b>YEAR</b>	<b>LAB/ CENTER</b>
<b>APG</b>	<b>Provide the EPA Program Offices, EPA Regions, States, utilities and others with improved tools for characterizing pathogens in biosolids</b>	<b>2004</b>	<b>ORD</b>
APM	Development and validation of methods for enumeration of fecal coliforms in biosolids to develop a draft EPA Method 1680 entitled "Fecal Coliforms in Biosolids by Multiple-Tube Fermentation Procedures"	2004	NRMRL
APM	Development and validation of methods for enumeration of salmonellae in biosolids to develop a draft EPA Method 1682 entitled "Salmonella in Biosolids by Enrichment, Selection and Biochemical Characterization"	2004	NRMRL
<b>APG</b>	<b>Provide the EPA Program Offices, EPA Regions, States and others with study findings that improve the understanding of the effectiveness of current biosolids practices and of the significance of human health risks to support decisions on biosolids management and research</b>	<b>2005</b>	<b>ORD</b>
<b>APM 147</b>	Report on the evaluation of contaminant concentrations and on the reduction of biosolids contaminants achieved by current biosolids management practices at field application sites	2005	NRMRL
APM	Risk Assessment Analysis Plan that defines needs for biosolids research to support NRC recommendations and 503(b) listings	2005	NCEA
<b>APG</b>	<b>Provide the EPA Program Offices, EPA Regions, States and others with improved data, tools, and methods for the analysis of risks, and for selection of more effective management options</b>	<b>2007</b>	<b>ORD</b>
APM	Methods for selected pharmaceutical and personal care products (PPCPs) (e.g., antibiotics and musks) adapted for solid materials	2005	NERL

APM	Reports on case studies of up to 7 biosolids production and/or application sites providing data on contaminant occurrence, treatment and application process cost-effectiveness and contaminant transport and fate for selected biosolids contaminants	2006	NRMRL
APM	An optimized method for measuring enteric viruses in biosolids	2006	NERL
APM	Improved risk assessment methodologies and assessment of key contaminants for land application of biosolids in support of 503 listings	2006	NCEA
APM	Improved pathogens risk assessment methodologies for regulatory decisions	2007	NCEA
APM	An optimized method for measuring helminth ova in biosolids	2007	NERL
APM	Report on small pilot survey to identify pharmaceutical and personal care products (PPCPs) in biosolids	2007	NERL

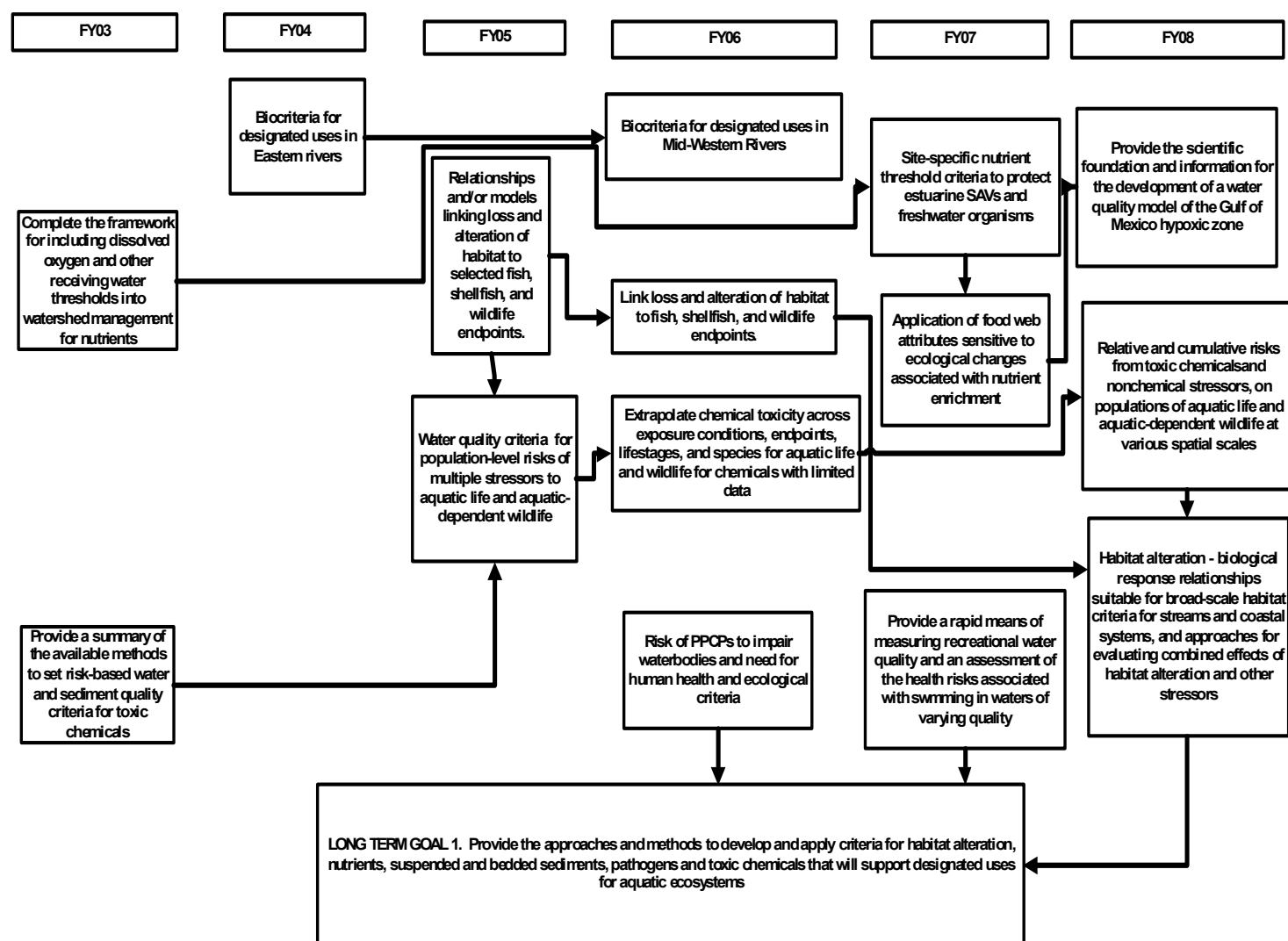


Figure 5. Long Term Goal 1

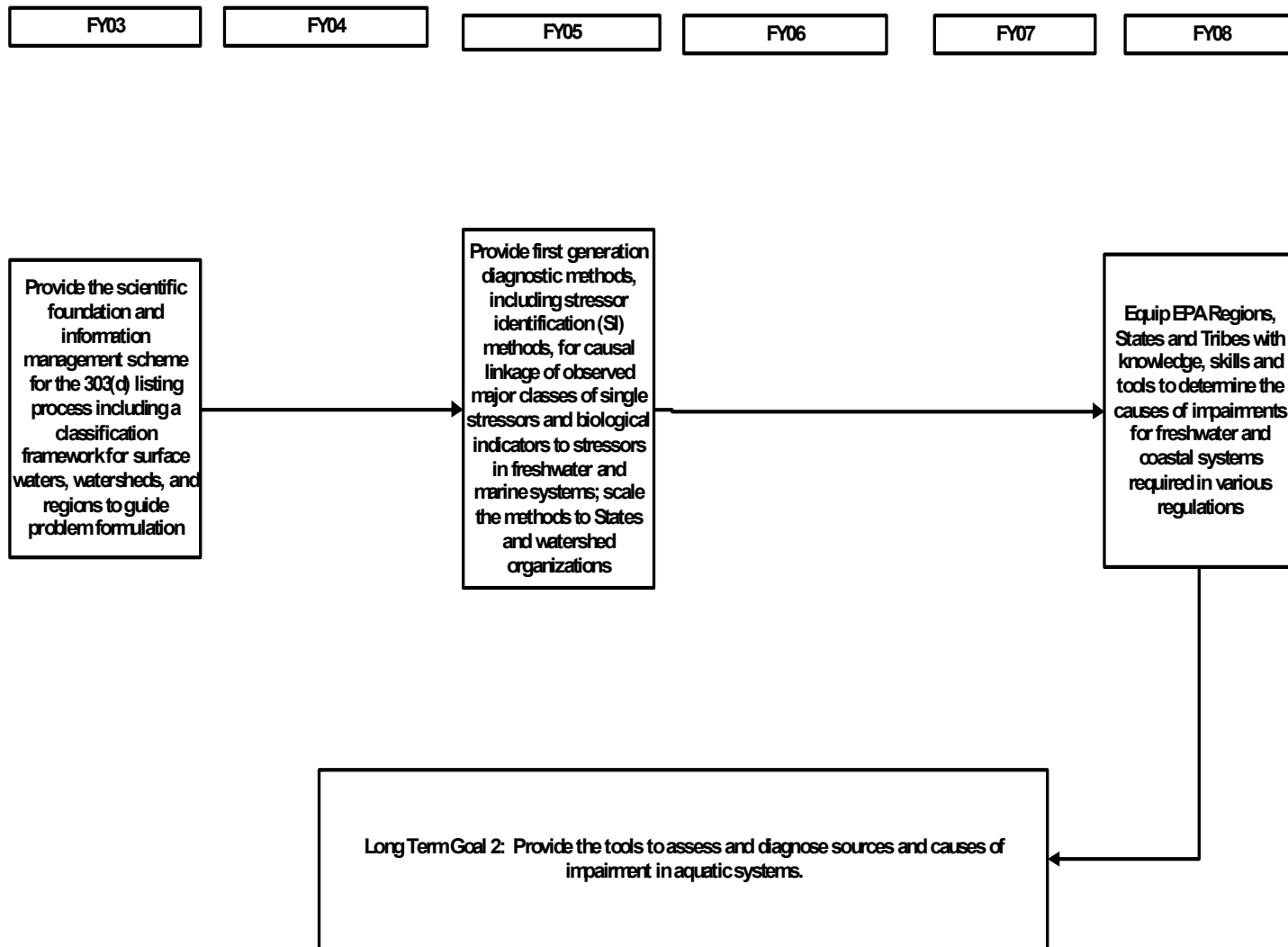


Figure 6. Long Term Goal 2

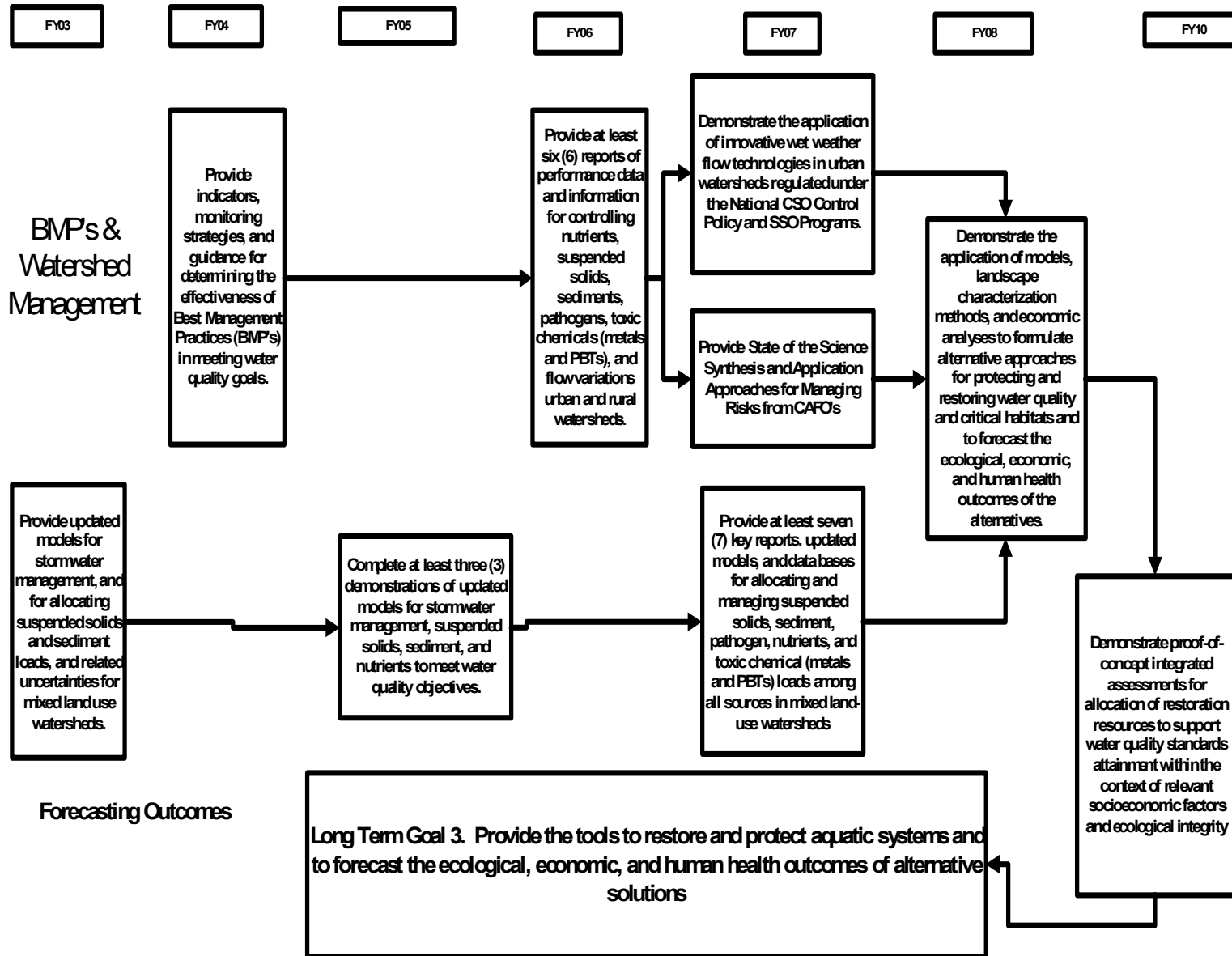


Figure 7. Long Term Goal 3

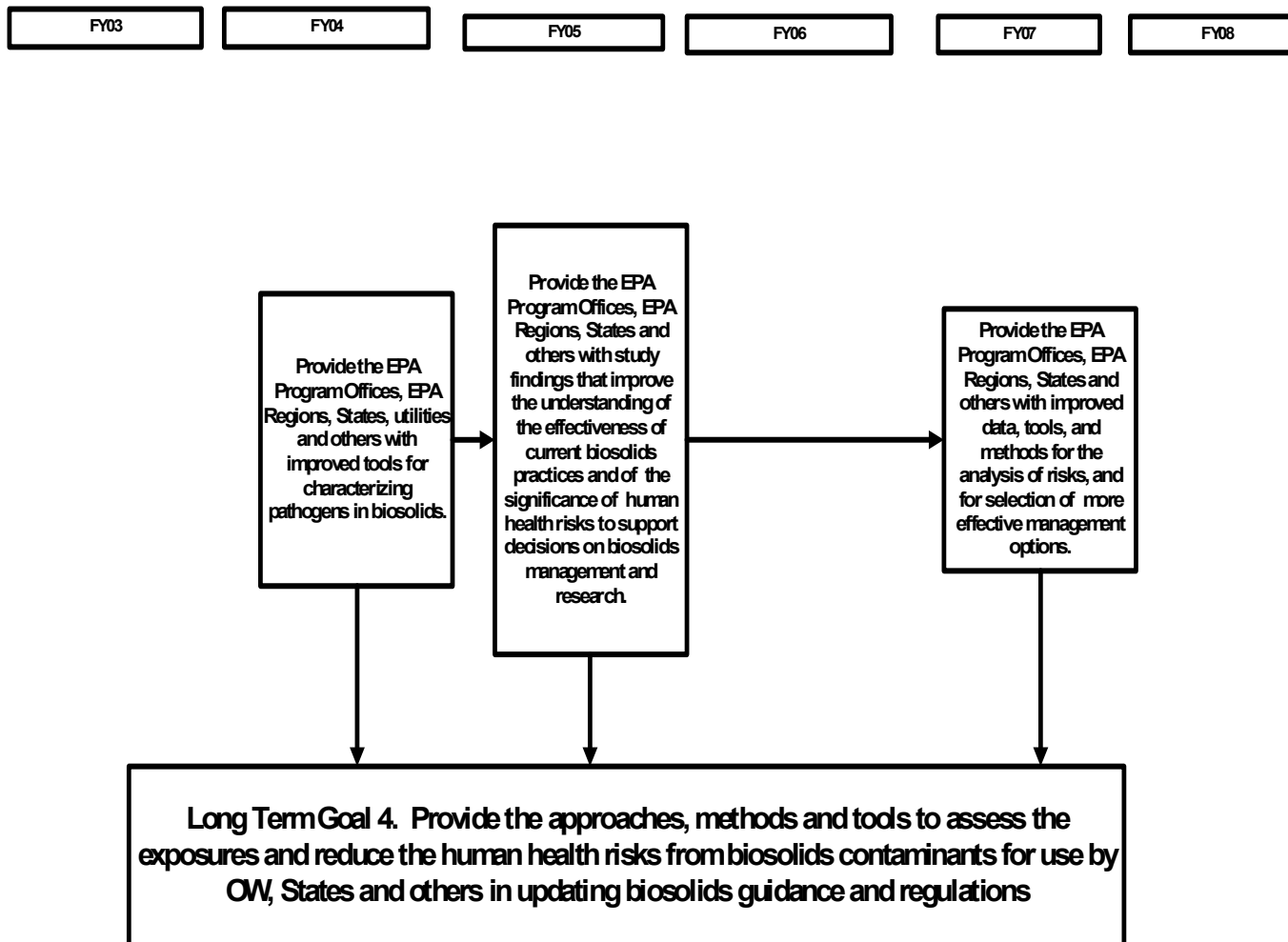


Figure 8. Long Term Goal 4

## APPENDIX



<b>EPA Strategic Plan Goals and Related ORD MYPs</b>	
<b>Goal</b>	<b>MYP</b>
Goal 1: Clean Air	Particulate Matter
	Air Toxics
	Tropospheric Ozone
Goal 2: Clean and Safe Water	Drinking Water
	Water Quality
Goal 3: Protect and Restore the Land	Resource Conservation and Recovery Act (RCRA)
	Contaminated Sites
Goal 4: Healthy Communities and Ecosystems	Mercury
	Global Change
	Ecological Research
	Human Health Risk Assessment
	Endocrine Disruptors
	Safe Pesticides/Safe Products
	Safe Food
Goal 5: Compliance and Environmental Stewardship	Economics and Decision Sciences
	Pollution Prevention and New Technologies for Environmental Protection

## LIST OF ACRONYMS

ACE	Acute-to-Chronic Estimation
AFLP	Amplified Fragment Length Polymorphisms
APG	Annual Performance Goal
APM	Annual Performance Measure
AWQC	Ambient Water Quality Criteria
BMP	Best Management Practice
CAFO	Confined Animal Feeding Operation
CDC	Centers for Disease Control
CFR	Code of Federal Regulations
CSO	Combined Sewer Overflow
CWA	Clean Water Act
DO	Dissolved Oxygen
EDC	Endocrine Disrupting Chemicals
EMAP	Environmental Monitoring and Assessment Program
EPA	Environmental Protection Agency
ERD	Ecosystems Research Division of NERL
ESD	Environmental Sciences Division of NERL
ETV	Environmental Technology Verification
EXTRAN	Extended Transport Module in Storm Water Management Model
FTE	Full Time Equivalent
GC/MS/SIM	Gas Chromatography/Mass Spectrometry - Selective Ion Monitoring
GIS	Geographic Information System
GPRA	Government Performance and Results Act
GSTARS	Generalized Stream Tube model for Alluvial River Simulation
GWERD	Ground Water and Ecological Restoration Division of NRMRL
HAB	Hazardous Algal Bloom
IBI	Index of Biotic Integrity
ICE	Ion Composition Elucidation
LC/MS	Liquid Chromatography/Mass Spectrometry
LRPCD	Land Remediation and Pollution Control Division of NRMRL
LTG	Long Term Goal
MCL	Maximum Contaminant Level
MS	Mass Spectrometry
MYP	Multi-year Plan
NAS	National Academy of Science
NAWQA	National Ambient Water Quality Assessment (within USGS)
NCEA	National Center for Exposure Assessment within EPA's Office of Research and Development
NCER	National Center for Environmental Research within EPA's Office of Research and Development
NEP	National Estuary Program
NERL	National Exposure Risk Laboratory within EPA's Office of Research and Development

NHEERL	National Health and Ecological Effects Research Laboratory within EPA's Office of Research and Development
NOAA	National Oceanic and Atmospheric Administration
NPS	Nonpoint Source
NRC	National Research Council of the National Academies
NRMRL	National Risk Management Laboratory within EPA's Office of Research and Development
NSF	National Science Foundation
OEPA	Ohio Environmental Protection Agency
OGWDW	Office of Ground Water and Drinking Water within EPA's Office of Water
ORD	Office of Research and Development
OSP	Office of Science Policy within EPA's Office of Research and Development
OST	Office of Science and Technology within EPA's Office of Water
OW	Office of Water
OWM	Office of Wastewater Management within EPA's Office of Water
OWOW	Office of Wetlands, Oceans and Watersheds within EPA's Office of Water
P2	Pollution Prevention
PBT	Persistent Bioaccumulative Toxic
PBTK/TD	Physiologically-Based Toxicokinetic/Toxicodynamic
PCO	Pfisteria Complex Organisms
POCIS	Polar Organic Chemical Integrative Sampler
PPCP	Pharmaceuticals and Personal Care Products
SAV	Submerged Aquatic Vegetation
SI	Stressor Identification
SDWA	Safe Drinking Water Act
SPRC	Strategic Planning and Research Coordination
SSO	Storm Sewer Overflow
SSRI	Selective Serotonin Reuptake Inhibitors
STD	Sustainable Technology Division of NRMRL
SWMM	Storm Water Management Model
TIE	Toxicity Identification Evaluation
TMDL	Total Maximum Daily Load
TVA	Tennessee Valley Authority
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WSWRD	Water Supply and Water Resources Division of NRMRL
WWT	Waste Water Treatment

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